HABITAT USE AND ACTIVITY PATTERNS OF MARBLED MURRELETS AT INLAND AND AT-SEA SITES IN THE QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA

Michael S. Rodway
Jean-Pierre L. Savard
Heidi M. Regehr

TECHNICAL REPORT SERIES No. 122
Pacific and Yukon Region 1991
Canadian Wildlife Service

Environment Canada
Environnement Canada

Canadian Wildlife Service
Service Canadien de la faune

Canada

91-06001/

TECHNICAL REPORT SERIES
CANADIAN WILDLIFE SERVICE

This series of reports, established in 1986, contains technical and scientific information from projects of the Canadian Wildlife Service. The reports are intended to make available material that either is of interest to a limited audience or is too extensive to be accommodated in scientific journals or in existing CWS series.

Demand for these Technical Reports is usually confined to specialists in the fields concerned. Consequently, they are produced regionally and in small quantities; they can be obtained only from the address given on the back of the title page. However, they are numbered nationally. The recommended citation appears on the title page.

Technical Reports are available in CWS libraries and are listed with the DOBIS system in major scientific libraries across Canada. They are printed in the official language chosen by the author to meet the language preference of the likely audience. **To determine whether there is significant demand for making the reports available in the second official language, CWS invites users to specify their official language preference. Requests for Technical Reports in the second official language should be sent to the address on the back of the title page.**

SÉRIE DE RAPPORTS TECHNIQUES
DU SERVICE CANADIEN DE LA FAUNE

Cette série de rapports donnant des informations scientifiques et techniques sur les projets du Service canadien de la faune (SCF) a démarré en 1986. L'objet de ces rapports est de promouvoir la diffusion d'études s'adressant à un public restreint ou trop volumineuses pour paraître dans une revue scientifique ou l'une des séries du SCF.

Ordinairement, seuls les spécialistes des sujets traités demandent ces rapports techniques. Ces documents ne sont donc produits qu'à l'échelon régional et en quantités limitées; ils ne peuvent être obtenus qu'à l'adresse figurant au dos de la page titre. Cependant, leur numérotage est effectué à l'échelle nationale. La citation recommandée apparaît à la page titre.

Ces rapports se trouvent dans les bibliothèques du SCF et figurent aussi dans les listes du système de référence DOBIS utilisé dans les principales bibliothèques scientifiques du Canada. Ils sont publiés dans la langue officielle choisie par l'auteur en fonction du public visé. **En vue de déterminer si la demande est suffisamment importante pour produire ces rapports dans la deuxième langue officielle, le SCF invite les usagers à lui indiquer leur langue officielle préférée. Il faut envoyer les demandes de rapports techniques dans la deuxième langue officielle à l'adresse indiquée au verso de la page titre.**

Cover illustration is by R.W. Butler and may not be used for any other purpose without the artist's written permission.

L'illustration de la couverture est une œuvre de R.W. Butler. Elle ne peut dans aucun cas être utilisée sans avoir obtenu préalablement la permission écrite de l'auteur.

HABITAT USE AND ACTIVITY PATTERNS OF MARBLED MURRELETS AT INLAND AND AT-SEA SITES IN THE QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA

Michael S. Rodway
Jean-Pierre L. Savard
and
Heidi M. Regehr

Technical Report Series No. 122
Pacific and Yukon Region 1991
Canadian Wildlife Service

This series may be cited as:

Rodway, M.S., J-P.L. Savard and H.M. Regehr. 1991. Habitat use and activity patterns of Marbled Murrelets at inland and at-sea sites in the Queen Charlotte Islands, British Columbia. Technical Report Series No. 122. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Printed on recycled paper

Issued under the Authority of the
Minister of the Environment
Canadian Wildlife Service

©Ministry of Supply and Services Canada 1991
Catalogue No. CW69-5/122
ISBN 0-662-18659-1
ISSN 0831-6481

Copies may be obtained from:

Canadian Wildlife Service,
Pacific and Yukon Region
P.O. Box 340,
Delta, British Columbia,
Canada, V4K 3Y3

TABLE OF CONTENTS

List of Tables iii
List of Figures iii
List of Appendices v
Abstract vii
Résumé viii
Acknowledgements ix

Introduction 1
Methods 2
  1. Survey methods 2
  2. Inland activity patterns and behaviour 3
  3. At-sea activity patterns 4
  4. Marbled Murrelet activity in relation to habitat type 4
  5. Vegetation sampling 9
Results 10
  1. Inland activity patterns 10
    1.1 Daily variability 10
    1.2 Seasonal activity patterns 12
      1.2.1 Mean number of detections 13
      1.2.2 Number of keer calls 18
      1.2.3 Calls per detection 18
      1.2.4 Duration of activity 20
    1.3 Comparison of morning and evening detections . . 20
    1.4 Effect of weather on murrelet activity 21
  2. Behaviour and group size 22
    2.1 Visual vs auditory detections 22
    2.2 Group size 25
    2.3 Height of flight 27
    2.4 Flight path 30
  3. At sea activity patterns 33
    3.1 Seasonal abundance and distribution in Long Inlet 33
    3.2 Seasonal abundance in Shields Bay 34
    3.3 Group size 34
    3.4 Plumage and breeding chronology 35
    3.5 Relation to inland activity levels 38
  4. Marbled Murrelet activity in relation to habitat type 40
    4.1 Habitat types 40
    4.2 Marbled Murrelet activity 42
      4.2.1 Old-growth forest and alpine habitat . . . 42
      4.2.2 Second-growth forest habitat 46
      4.2.3 Other areas 51
  5. Geographical distribution of Marbled Murrelets . . 56
    5.1 At-sea surveys 56
      5.1.1 Gray Bay to Cumshewa Head 56
      5.1.2 Masset Sound 56
      5.1.3 North coast of Graham Island 57
      5.1.4 Shields Bay and Rennell Sound 57
      5.1.5 Skidegate Inlet area 57
    5.2 Inland surveys 58
      5.2.1 Breaker Bay 58

Table of Contents (continued)

5.2.2 Deena River 58
5.2.3 Government Creek 59
5.2.4 Gray Bay 59
5.2.5 Hangover Creek 60
5.2.6 Honna River 60
5.2.7 Ian Lake 60
5.2.8 Jungle Creek 61
5.2.9 Mercer Lake 61
5.2.10 Naikoon Park 61
5.2.11 Phantom Creek 62
5.2.12 Skidegate Lake 62
5.2.13 Yakoun Lake 62
5.2.14 Other lakes 63

Discussion 63
1. Inland activity patterns 63
1.1 Daily and seasonal activity patterns 63
1.2 Effect of weather on murrelet activity 64
1.3 Correlation of murrelet activity between sites . 65
2. Behaviour 65
3. At-sea activity patterns 67
3.1 Seasonal abundance 67
3.2 Group size and breeding chronology 68
3.3 Abundance at-sea in relation to activity levels at adjacent inland stations 70
4. Function of Marbled Murrelet flight activities . . 70
4.1 Nest searching 70
4.2 Mating behaviour 72
4.3 Spacing behaviour 72
4.4 Flight corridors 73
4.5 Others 73
5. Marbled Murrelet activity in relation to habitat type 74
6. Survey methods and considerations 74
7. Recommendations 76
8. Concluding remarks 78

Summary 79

Literature cited 81

Appendices 86

List of Tables

1. Numbers of Marbled Murrelet detections recorded on evening and following morning surveys at both permanent stations from May to July, 1990 21

2. Mean number of Marbled Murrelet detections per survey in foggy/cloudy and clear weather during May, June and July 25

3. Mean duration of Marbled Murrelet activity per survey in foggy/cloudy and clear weather during May, June and July 25

4. Relationship between the number of Marbled Murrelets in Long Inlet and the level of murrelet activity in the forest at Lagins Creek Station 16 39

5. Mean tree diameter at breast height (DBH) within site association and vegetation groups in the Lagins Creek study area 41

6. Kruskal-Wallis test results for comparisons of numbers of Marbled Murrelet detections in old-growth forest at low elevation, old-growth forest at high elevation, and alpine habitat at Lagins Creek 43

7. Results of Z tests for comparisons of proportions of Marbled Murrelet detections occurring within 500, 150 and 50 m radii of survey stations in low elevation forest, high elevation forest, and alpine habitat at Lagins Creek from May through July 45

List of Figures

1. Location of Marbled Murrelet survey sites in the Queen Charlotte Islands 152

2. Location of Marbled Murrelet survey sites at Lagins Creek 5

3. Weekly and seasonal variability of Marbled Murrelet forest activity at Lagins and Phantom Creeks 11

4. Relative seasonal level of Marbled Murrelet forest activity at the two permanent stations 14

5. Weekly means of Marbled Murrelet detections and mean activity duration at the two permanent stations . . 15

List of Figures (continued)

6. Seasonal trend in the number of detections at Lagins Creek 16

7. Seasonal trend in the number of detections at Phantom Creek 17

8. Weekly means of Marbled Murrelet calls per survey and calls per detection at the two permanent stations . 19

9. Marbled Murrelet detections in relation to sunrise and weather at Lagins and Phantom creeks 23

10. Seasonal variation in Marbled Murrelet detections in relation to sunrise and weather at Lagins and Phantom creeks 24

11. Frequency of Marbled Murrelet sightings in relation to group sizes 26

12. Frequency of silent and vocal visual sightings of Marbled Murrelets in relation to group size and flying altitude 28

13. Seasonal frequency of Marbled Murrelet sightings in relation to flying altitude 29

14. Frequency of Marbled Murrelet sightings in relation to group sizes and flight patterns 31

15. Frequency of silent and vocal visual sightings of Marbled Murrelets in relation to group size and flying patterns 32

16. Seasonal variations in Marbled Murrelet group sizes in Long Inlet and Shields Bay 36

17. Relative frequency of single and paired Marbled Murrelets in Long Inlet and Shields Bay 37

18. Mean number of Marbled Murrelet detections in low elevation and high elevation old-growth forests and in alpine habitats 44

19. Mean number of Marbled Murrelet detections per road side station in relation to adjacent habitat type 47

20. Number and distribution of road side stations with detections of Marbled Murrelets in May 48

List of Figures (continued)

21. Number and distribution of road side stations with detections of Marbled Murrelets in June 49

22. Number and distribution of road side stations with detections of Marbled Murrelets in July 50

23. Comparison of the number and location of Marbled Murrelet detections in various stations at Mercer Lake in July (1 count per station) 52

24. Comparison of the number and location of Marbled Murrelet detections in various stations at Phantom Creek in early May (maximum of 2 or 3 counts) 53

25. Number of Marbled Murrelet detections recorded at various stations located near old-growth forest in May 1990 54

26. Number of Marbled Murrelet detections (maximum) recorded at various stations located near old-growth and second-growth forest in July 1990 (OG=old growth; SG=40-60 years old; (number of surveys) 55

List of Appendices

1. Key to Marbled Murrelet fixed station detection record 86

2. Marbled Murrelet detections at Lagins Creek station 16, from May to July summarized weekly 90

3. Marbled Murrelet detections at Phantom Creek station 12, from May to August summarized weekly 91

4. Means and distribution by month of the time of Marbled Murrelet detections relative to sunrise at Lagins and Phantom creeks 93

5. Proportion of Marbled Murrelet visual detections at different heights, categorized by group size and vocalization 94

6. Proportion of Marbled Murrelet visual detections with different flight behaviours, categorized by group size and vocalization 96

7. Daily and seasonal abundance of Marbled Murrelet in Long Inlet in 1990 98

8. Marbled Murrelet distribution in Long Inlet from May to July 1990 100

List of Appendices (continued)

9. Mean daily and weekly numbers of Marbled Murrelets in Long Inlet and Shields Bay from May to July 1990 . . 101

10. Group size of Marbled Murrelet flocks in Long Inlet and Shields Bay in 1990 102

11. Summary of vegetation data sorted into vegetation groups from habitat plots surveyed in Lagins and Phantom creeks 104

12. Tukey HSD multiple comparisons of mean DBH amongst site associations and vegetation groups in Lagins Creek study area: matrix of pairwise comparison probabilities . 109

13. Marbled Murrelet detections at stations in low and high elevation old-growth forest and alpine habitat at Lagins Creek, 1990 110

14. Marbled Murrelet detections at inland locations surveyed outside the main study area from May to July 1990 . 113

15. Marbled Murrelet activity along road transects through second-growth and old-growth forest habitats in May, June and July 1990 116

16. Reimchen, T.E. 1991. Marbled Murrelet habitat use near lakes in the Queen Charlotte Islands 120

17. Summary of boat and telescope surveys of Marbled Murrelets carried out in the Queen Charlotte Islands 140

Abstract

The major objective of this study was to characterize and quantify the activity of Marbled Murrelets (Brachyramphus marmoratus) at inland and at-sea sites in the Queen Charlotte Islands. The number of Marbled Murrelet detections at a given inland site was highly variable with coefficient of variations around 30-40%. More Marbled Murrelets were detected at inland sites and the duration of the activity period was longer on cloudy mornings than on clear mornings. Marbled Murrelet detections were between 2 to 40 times more numerous during morning surveys than evening surveys. Daily level of detections were not always correlated between the two inland sites monitored on a weekly scale, but were highly correlated on a seasonal scale (May to July). The number of inland detections was lower in May than June and highest in July, dropping sharply to nearly zero in early August. Most detections (74 to 81%) were auditory only, making it difficult to characterize bird behaviour. Approximately half of the visual detections were of silent birds. Most birds sighted were either single or in pairs. Groups of three birds or more tended to fly higher over the canopy and to be more vocal than smaller groups.

The abundance of Marbled Murrelets in Long Inlet varied daily, weekly and seasonally. The seasonal abundance of murrelets in Long Inlet was correlated with the number of murrelet detections at an adjacent inland site, being higher in May than June and highest in July.

The number of Marbled Murrelet detections was higher in old-growth forests than in alpine areas where murrelet detections were mostly of distant birds flying below in the valley. Nest searches in the alpine area in late May and early June failed to flush any birds. There were indications that some murrelets fly over alpine areas en route to valleys. The number of Marbled Murrelet detections was higher in low elevations than high elevation old-growth forests in May and July but not in June. Roadside transects located adjacent to old-growth forest had more frequent Marbled Murrelet detections than stations adjacent to second-growth forests. Fixed stations in 40-60 year old forests had very few murrelet detections and these detections were mostly of distant birds.

The study supports the association of Marbled Murrelets with old-growth forests, but indicates that caution is needed when interpreting inland murrelet detections. Correlations between inland activity levels and at-sea abundance is encouraging but need to be investigated at a larger scale.

Résumé

L'objectif principal de cette étude était de characterizé et de quantifié l'activité en forêt et à la mer de l'alque marbré (*Brachyramphus marmoratus*) dans les îles de la Reine Charlotte. Le nombre de détections visuelles ou audibles à un site forestier donné était trés variable avec un coéficient de variation de 30 à 40%. La durée de la période d'activité de l'alque marbré et le nombre de détections était plus élevé lors de matins nuageux qu'ensoleillés. Le nombre de détections d'alques marbrés était de 2 à 40 fois plus élevé le matin que le soir. Les observations à deux sites forestiers distincts indiquèrent que le nombre de détections n'était pas toujours correlé au niveau d'une semaine mais l'était fortement à l'échelle saisonière (de mai à juillet). Le nombre de détections en forêt était plus élevé en juin qu'en mai, et plus élevé en juillet qu'en juin pour décliner à presque rien en août. La plupart des détections (74 à 81%) étaient seulement à l'oreil, rendant difficile la charactérization du comportement des alques en forêt. Près de la moitié des détections visuelles impliquaient des oiseaux silencieux. La plupart des oiseaux observés visuellement étaient soit seuls soit en couple. Les groupes de trois oiseaux ou plus avaient tendance à voler plus haut et à être plus vocals que les groupes plus petits.

L'abondance de l'alque marbré dans le fiord Long variait d'un jour, d'une semaine et d'un mois à l'autre. L'abondance mensuelle de l'alque marbré dans le fiord Long était correlé avec le nombre de détections dans un site forestier adjacent, étant plus élevé en mai qu'en juin et le plus élevé en juillet. Le nombre de détections d'alque marbré était beaucoup plus élevé dans les forêts anciennes que dans la zone alpine où les détections étaient surtout d'oiseaux éloignés volant au dessus de la vallée. La recherche de nids en zone alpine en mai et juin s'est revélée négative. Certains alques furent observés au vol passant dans la zone alpine en route vers les vallées adjacentes. Le nombre de détections d'alque marbré était plus élevé dans les forêts anciennes de la vallée que dans celles à plus haute altitude en mai et juillet mais pas en juin où le nombre de détections était similaire. Le nombre de détections d'alques marbré dans les transects routiers était beaucoup plus élevé pour les transects adjacents à des forêt anciennes que pour ceux adjacents à des forêts en régénération. Les stations fixes localisées dans des forêts de 40 à 60 ans avaient très peu de détections d'alque marbré et ces détections étaient surtout d'oiseaux éloigés, on volant à haute altitude.

Notre étude supporte la préférence apparente de l'alque marbré pour les forêts anciennes et suggère la prudence dans l'interprétation des détections d'alques marbrés en milieu forestier. La correlation observée entre le niveau de détection en forêt et l'abondance de l'alque marbré à l'eau est encouragente mais nécessite d'être confirmée sur une plus grande échelle.

Acknowledgements

This research project resulted from the efforts and cooperation of several individuals. In 1989, the Canadian Wildlife Service did some preliminary surveys to measure Marbled Murrelet activity in the forests of the Greater Vancouver Watershed and the Carmanah Valley. These surveys, along with the results of the research efforts in the United States raised concerns for the well-being of the Marbled Murrelet in British Columbia especially in light of our lack of knowledge about the ecology of the species.

In the fall of 1989, an informal committee was formed to help generate funds and research on Marbled Murrelets. Initial members of the committee were Fred Bunnell, Forestry U.B.C., Wayne Campbell, Royal B.C. Museum, Gary Kaiser and Jean-Pierre Savard, Canadian Wildlife Service, and Ron McLaughlin and Bill Pollard of MacMillan Bloedel. At their first meeting, the committee decided: 1) to commission a report on the status of the Marbled Murrelet in British Columbia; 2) to prepare a proposal for research on the Marbled Murrelet in 1990-91; and 3) to solicit and consolidate funds for research on the Marbled Murrelet. MacMillan Bloedel supported the production of the status report by contracting Michael Rodway to write it. Ron McLaughlin undertook the task of soliciting partners and funds for murrelet research, and the Canadian Wildlife Service produced a preliminary research proposal. The British Columbia Conservation Foundation directed by Bob Moody, agreed to oversee the administration of the research fund.

In the winter of 1990, a broader committee was established to oversee and approve the research proposal. This committee included: Fred Bunnell, Forestry U.B.C.; Wayne Campbell, Royal B.C. Museum; Bill Dumont, Western Forest Products; Dave Husby and Arnold Pertile, Husby Forest Products Ltd.; Gary Kaiser and Jean-Pierre Savard, Canadian Wildlife Service; Dave Lindsay, Fletcher Challenge; Ron McLaughlin and Bill Pollard, MacMillan Bloedel; Bob Moody, B.C. Conservation Foundation; Dale Seip, Ministry of Forests; Bob Redhead and Doug Burles, Canadian Parks Service. The research was supervised by Jean-Pierre Savard and a field team was assembled to conduct the field work. Michael Rodway was the field leader of the project and oversaw all aspects of the field work. Members of the research team included Moira Lemon, Don Garnier, Audrey Pearson and Heidi Regehr. Field work by Heidi Regehr was funded by Malcom Ramsay of the University of Saskatchewan. Audrey Pearson collected and analysed habitat data. The detail of this study could not have been accomplished without the dedicated assistance of four volunteers. Inez and Tom Weston transported themselves to the study site and maintained vigilance at Phantom Creek permanent station 12 for the month of May. They were completely self-supporting. Kerry Baker and Julie Stoneman were an integral part of the research team for the month of July. They "manned" fixed stations in Lagins Creek and Gray Bay, under often arduous conditions. We thank all the volunteers for their generous help and their wonderful company.

Members of the old-growth biodiversity study supervised by Dale Seip and Jean-Pierre Savard also contributed to murrelet data acquisition. They were Margo Hearne, Linda Dupuis and Steve Hamel. Margo Hearn also contributed past records of Marbled Murrelets along the north coast of Graham Island. We thank all the cooperators for their helpful contribution.

Administrative support was provided by Bob Moody and Deborah Gibson of the B.C. Conservation Foundation, and their assistance was invaluable in the successful realization of the project. The B.C. Conservation Foundation also helped in entering the field data on the computer, a monumental task. We especially thank Dianne Rose-Talarico for her efforts.

Fred Bunnell's assistance in the design, revisions and submission of various research proposals to various funding agencies was invaluable.

Ron McLaughlin's efforts in seeking cooperative agencies, scheduling committee meetings and consolidating funds were crucial in the realization of this project.

Several people helped with logistic problems and we thank them: Gene Matchitt, Lorne McIntosh, Keith Moore and Ken Morgan.

We thank Kim Nelson who kept us updated with concurrent murrelet research in the United States and Moira Lemon who drafted the maps for the report.

Special acknowledgements to the contributing agencies who made this research possible:

B.C. Ministry of Forests
B.C. Ministry of Environment
B.C. Ministry of Parks
Canadian Wildlife Service
Fletcher Challenge Canada
Husby Forest Products Ltd.
MacMillan Bloedel
Canadian Parks Service
Western Forest Products
World Wildlife Fund

We would like to acknowledge the foresight and genuine concern of the forest companies who helped in the realization of this project. They realized the need for solid scientific information upon which to base management and conservation decisions, and supported the project from beginning to end.

We thank Tom Reimchen for some of his insights on murrelet research and especially for his pioneer work in terms of documenting inland murrelet activity in the Queen Charlotte Islands.

The committee also supported, in part, research efforts on at-sea distribution of Marbled Murrelets near Powell River, B.C. directed by Gary Kaiser. The results of this research will appear in a separate Canadian Wildlife Service technical report.

We hope that similar cooperation will continue in coming years, so that we can rapidly increase our understanding of Marbled Murrelet ecology and thus incorporate sound scientific information in our management decisions.

INTRODUCTION

The Marbled Murrelet (Brachyramphus marmoratus) is widely distributed in nearshore waters of British Columbia. It is known to nest on the ground in alpine areas and on treeless maritime islands in Alaska (Hoeman 1965; Simons 1980; Hirsch et al. 1981; Day et al. 1983; Johnstone and Carter 1985) and in large trees in old-growth forest habitat from southern Alaska to California (Binford et al. 1975; Quinlan and Hughes 1984; Singer et al. in prep.). Studies in Washington, Oregon, and California indicate dependance on old-growth forest for nesting in the southern portion of the species range (Nelson et al. 1987; Carter and Erikson 1988; Marshall 1988; Paton and Ralph 1988; Nelson 1989; Varoujean et al. 1989). Data from British Columbia suggest similar use of old-growth forest habitat (Rodway 1990, Reimchen 1991; see Appendix 16). Conservation problems posed by the rapid removal of old-growth forest nesting habitat by logging, as well as by at-sea mortality from oil spills and gill-net fisheries, highlight the need to define distribution and nesting habitat requirements of Marbled Murrelets in British Columbia (Carter and Sealy 1984; Sealy and Carter 1984).

The objectives of this study were:

1. To monitor daily, seasonal and geographical variability in Marbled Murrelet activity patterns at inland and adjacent at-sea sites;

2. To evaluate the effects of weather on inland activity;

3. To compare the level of Marbled Murrelet activity in four broad habitat types - alpine, old-growth forest at high elevation, old-growth forest at low elevation, and second-growth forest (40-60 years old); and

4. To census Marbled Murrelet activity in as many inland locations as time permitted.

The study was conducted on the Queen Charlotte Islands, primarily on Graham Island, between 22 April and 23 August 1990.

METHODS

1. Survey methods: Methodology was adapted from Paton et al. (1988 - see Appendix 1). Both intensive surveys at fixed stations and general surveys along road transects were used. Morning surveys at fixed stations were initially conducted from 45 minutes before to 75 minutes after sunrise, but times were changed to 75 minutes before to 45 minutes after sunrise on 15 May when it became apparent that Marbled Murrelet activity times occurred earlier in the Queen Charlotte Islands than further south, probably due to longer twilight periods (see Results). If murrelets were still active at the end of the standard survey period, observations were continued until there was a 15 minute interval since the last detection. Evening surveys were conducted from 45 minutes before to 75 minutes after sunset. Eight to 10 stations, spaced at 1 km intervals, were surveyed for 10 minutes each along road transects, beginning 75 minutes before sunrise. We used sunrise and sunset times for Sandspit, provided by Atmospheric Environment Service, Environment Canada. All times are Pacific Standard Time.

We attempted to count all "keer" calls heard, but when that was impossible, we used "M" to record multiple calls >10. To analyse total keer calls heard, we replaced "M" with the average of all known counts of >10 calls recorded at stations in Lagins and Phantom creeks (see pg. 18). Total number of keer calls and total number of birds estimated per survey were correlated with total detections to assess whether they provided similar measures of murrelet activity.

2. Inland activity patterns and behaviour: Data on activity patterns and behaviour were collected at two permanent stations located along Lagins Creek and Phantom Creek (Fig. 1). Concurrent, morning surveys were conducted for 5-day periods every second week from May through July. Additional morning and evening surveys were made at each station, extending until 23 August at Phantom Creek. Daily and seasonal activity patterns at each site were compared and correlated with local weather conditions. Regressions were performed on the number of detections per survey versus date to analyse changes from month to month and over the entire season. A 2-way ANOVA was used to separate effects of weather from seasonal changes. Weather conditions were divided into two categories: fog or ≥ 80% cloud and < 80% cloud. The duration and timing of activity relative to sunrise were also compared between these two weather categories.

3. At-sea activity patterns: We conducted surveys in Long Inlet off Lagins Creek and in Shields Bay off Phantom Creek to monitor at-sea abundance and activity adjacent to inland sites known to be frequented by Marbled Murrelets (Fig. 1). Surveys were done for 4 consecutive days every second week between 16 May and 27 July. Long Inlet was surveyed by inflatable boat 8 times per day at 2 h intervals beginning 30 minutes after sunrise. Shields Bay was surveyed by telescope from shore over the same period (Fig. 1). The start and end times were the earliest and latest that it was dependably light enough to allow good visibility. Boat surveys were not done when sea conditions impaired visibility. Long Inlet was divided into 4 sections (Fig. 2) to characterize the distribution of murrelets within the area. At-sea surveys coincided with inland morning surveys at fixed stations, and mean and maximum daily counts on the water were correlated with numbers of detections recorded at inland stations.

4. Marbled Murrelet activity in relation to habitat type: We chose a confined study site to minimize the anticipated problem of distinguishing birds that are using an area from those that are flying through to other areas. Lagins Creek was considered optimal because the valley is encircled by high, alpine ridges, which we felt would deter birds from using it as a flyway to other valleys.

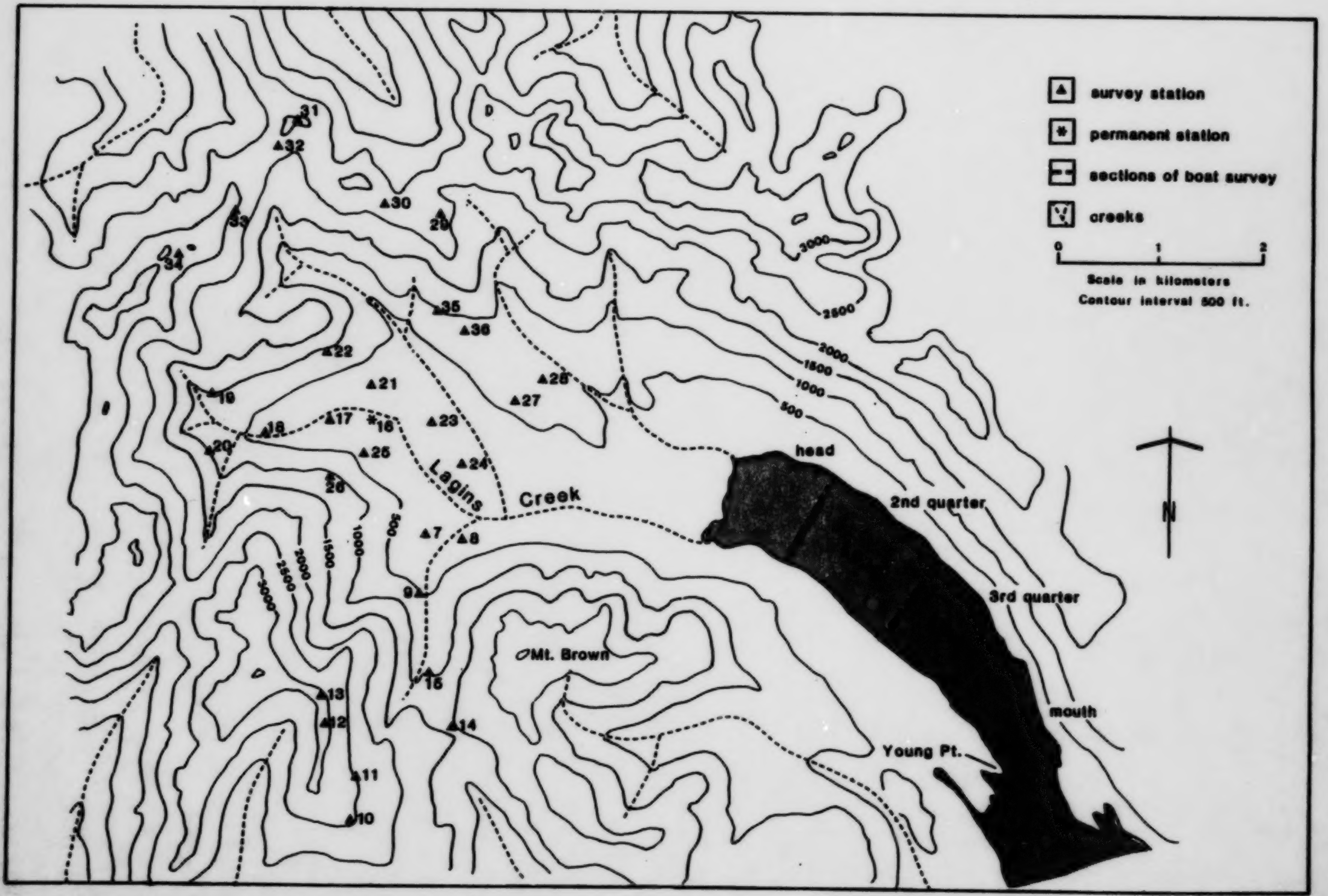


Figure 2. Location of Marbled Murrelet survey sites at Lagins Creek.

We had hoped to sample all four habitat types in the same area, but were unable to find a site which gave adequate representation of all types. We surveyed alpine habitat, old-growth forest at high elevation, and old-growth forest at low elevation in the Lagins Creek valley. Second-growth forest over the lower sections of the valley, which had been logged in the 1970's, was considered too young to be used for sampling that habitat type. Survey stations were distributed laterally up the valley sides from the valley bottom, placed at 90 to 150 m elevation for low-elevation forest; 230 to 460 m elevation for high-elevation forest; and 720 to 1000 m elevation for alpine habitat. Ten fixed stations were established in each habitat type (Fig. 2), and were surveyed once a month during May, June, and July. For logistic and safety reasons, stations were located and surveyed in pairs, with an average distance of 500 m between pairs of plots. One station in a high activity area on the valley floor was censused every morning during the survey period to provide a control for daily and seasonal variations in activity patterns. We used the median number of detections recorded at that station during each monthly survey period as one of the 10 samples of activity in low-elevation forest. Kruskal-Wallis tests were used to compare the number of detections per station in each habitat type. Months were tested separately and combined. We analysed the number of detections within 500, 150, and 50 m of survey stations to separate local from distant activity, as well as to compensate for different hearing ranges in different habitats. Proportions of detections within those radii were calculated according to the formula:

$$R = \frac{\bar{x}}{\bar{y}}$$

where x_i is the number of detections within a specific radius at the i^{th} station, and y_i is the total number of detections at the i^{th} station, and $\bar{x}$ and $\bar{y}$ are, respectively, the mean of the x_i and y_i over all stations.

The variance of R is calculated from:

$$Var(R) = \frac{\bar{x}^2}{\bar{y}^2} \left[\frac{s_x{}^2}{\bar{x}^2} + \frac{s_y{}^2}{\bar{y}^2} - \frac{2s_{xy}{}^2}{\bar{x}\bar{y}} \right]$$

where s_x is the standard error of $\bar{x}$, s_y is the standard error of $\bar{y}$, and $s_{xy}{}^2$ is the covariance of $\bar{x}$ and $\bar{y}$ (Kendall and Stewart 1963).

The standard error of R is the square root of Var(R). Differences in the proportion of detections within each radii were compared between habitat types using "z" tests. It should be emphasized that the proportions we calculated were not mutually exclusive, detections within 500 m included those within 150 m, and comparisons were made between habitats for a given radius and not between radii.

In alpine habitat, we conducted nest searches in the vicinity of survey stations and along accessible ridges between stations. Cavities and crevices under boulder piles, and sheltered sites around rocks and under shrubbery were inspected, and open heather meadows and bare rocky areas were traversed in an attempt to see or flush birds at nests.

We used both fixed stations and road transects to sample murrelet activity in second-growth forest. Five fixed stations were surveyed in extensive tracts of 60-80 year old forest along Skidegate Lake on Moresby Island and 100-120 year old forest near Jungle Creek on the east coast of Graham Island (Fig. 1). Stations were surveyed in July when activity levels in the old-growth forest habitat had peaked. Fifty-two stations along six road transects were surveyed once a month during May, June, and July (Fig. 1). Some of the road transects passed through pockets of old-growth forest and provided comparisons of murrelet activity in adjacent old-growth and second-growth forest habitat. Habitat at road stations was classified into four forest types according to the codes on 1:20,000 forest cover maps: #1 - Sitka Spruce (Picea sitchensis)/Western Hemlock (Tsuga heterophylla) old- growth forest; #2 - Western redcedar (Thuja plicata) and/or Yellow Cedar (Chamaecyparis nootkatensis)/Western Hemlock old-growth forest; #3 - second- growth forest 20-60 years old; and #4 - second-growth forest 60-120 years old. Numbers of detections per station in each type were compared using the same tests described above for fixed stations. Data from road stations surveyed later than 35-45 minutes after sunrise, when murrelet activity had generally ceased, were excluded from analyses.

Fixed stations were also distributed in different habitats in other valleys investigated to provide data on murrelet activity patterns which could be compared to those observed in Lagins Creek.

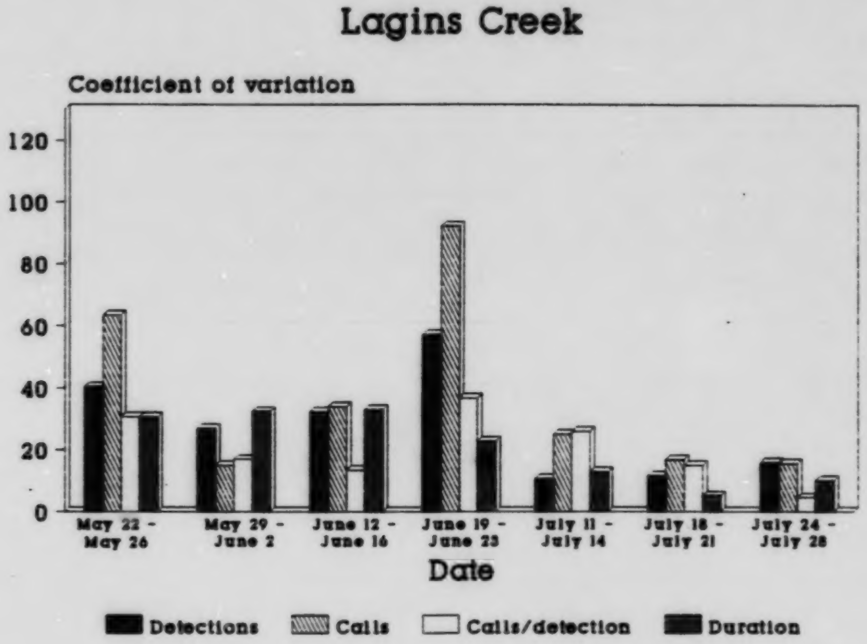
5. Vegetation sampling: Although the focus of monitoring Marbled Murrelet activity was to compare activity levels in broad habitat types, we collected detailed information on habitat parameters and vegetation composition in forested areas where fixed stations were located to accurately describe the habitat being sampled. Sampling followed the standard methods of the biogeoclimatic zone approach (Pojar et al. 1987) with one exception: plots were 30x30 m to better sample large trees. Data were collected in 20 plots (15 at Lagins Creek and 5 at Phantom Creek), selectively placed adjacent to murrelet survey stations in areas that were considered representative of the surrounding forest habitat. In each plot, cover of all plant species was recorded by species significant codes and percentage cover of each strata was estimated (Walmsley et al. 1980). The diameter at breast height (dbh) and species of each tree were recorded. Because mean dbh of trees within a plot do not describe the forest well or detect variation in size of dominant trees (due to the wide range of tree sizes in old-growth forest - Spies and Franklin 1988), we stratified dbh measurements into 50 cm diameter classes (10-50, 51-100, 101-150, etc.) and used trees in the two largest classes to calculate average diameters of dominant species. Trees less than 10 cm were not included. Differences in mean dbh among site associations and vegetation groups were tested by the Tukey HSD test (Wilkinson 1989). Reciprocal averaging was used to sort the plots into vegetation groups. These groups were then used as a basis for a vegetation hierarchy, using the tabular method of the Braun-Blaunquet approach (Pojar et al 1987). Groupings could not be tested through principal component analysis because the sample size was too small. Hierarchical groupings were informally named following Lewis (1982). Soil moisture and nutrient regimes were determined for each plot and used to classify it into a site association (Banner et al. 1990). In other locations where murrelet activity was censused but no vegetation plots were established, we categorized forest habitat to site association based on general vegetation and environmental descriptions. Murrelet activity levels in different site associations and vegetation groups were compared using Kruskal-Wallis tests.

RESULTS

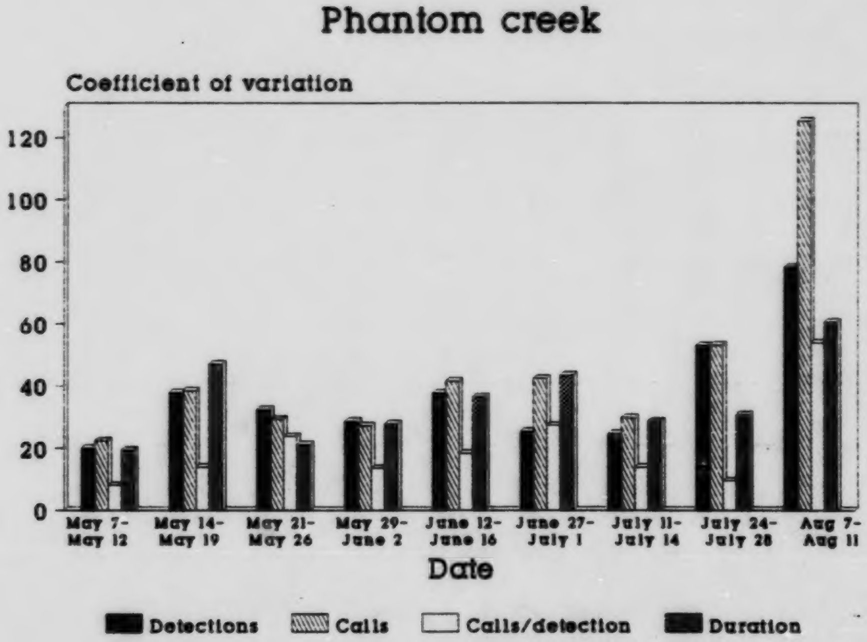
1. Inland activity patterns:

1.1. Daily variability:

Daily variation in the number of detections, the number of calls, the number of calls per detection and the duration of the activity period was high. We calculated the coefficient of variation ((standard deviation/mean)*100) for each of those parameters on a weekly basis for the permanent stations at Lagins Creek and Phantom Creek (Fig. 3). At Lagins Creek, the number of calls and the number of detections were the most variable parameter



Lagins Creek



Phantom creek

Figure 3. Weekly and seasonal variability of Marbled Murrelet forest activity at Lagins and Phantom Creeks.

measured (mean CV = 37.4 and 27.8 respectively). At Phantom Creek, daily variability was highest for the number of calls (mean CV = 45.6), similar for the number of detections (CV = 37.7) and the length of the activity period (CV = 35.1), and lowest for the number of calls per detection (CV = 20.3).

The variability of these parameters fluctuated during the summer. At Lagins Creek, there was a general increase in the variability of these parameters in mid-June and a reduction in variability in July. At Phantom Creek, the variability was lowest in early May and highest in early August (Fig. 3).

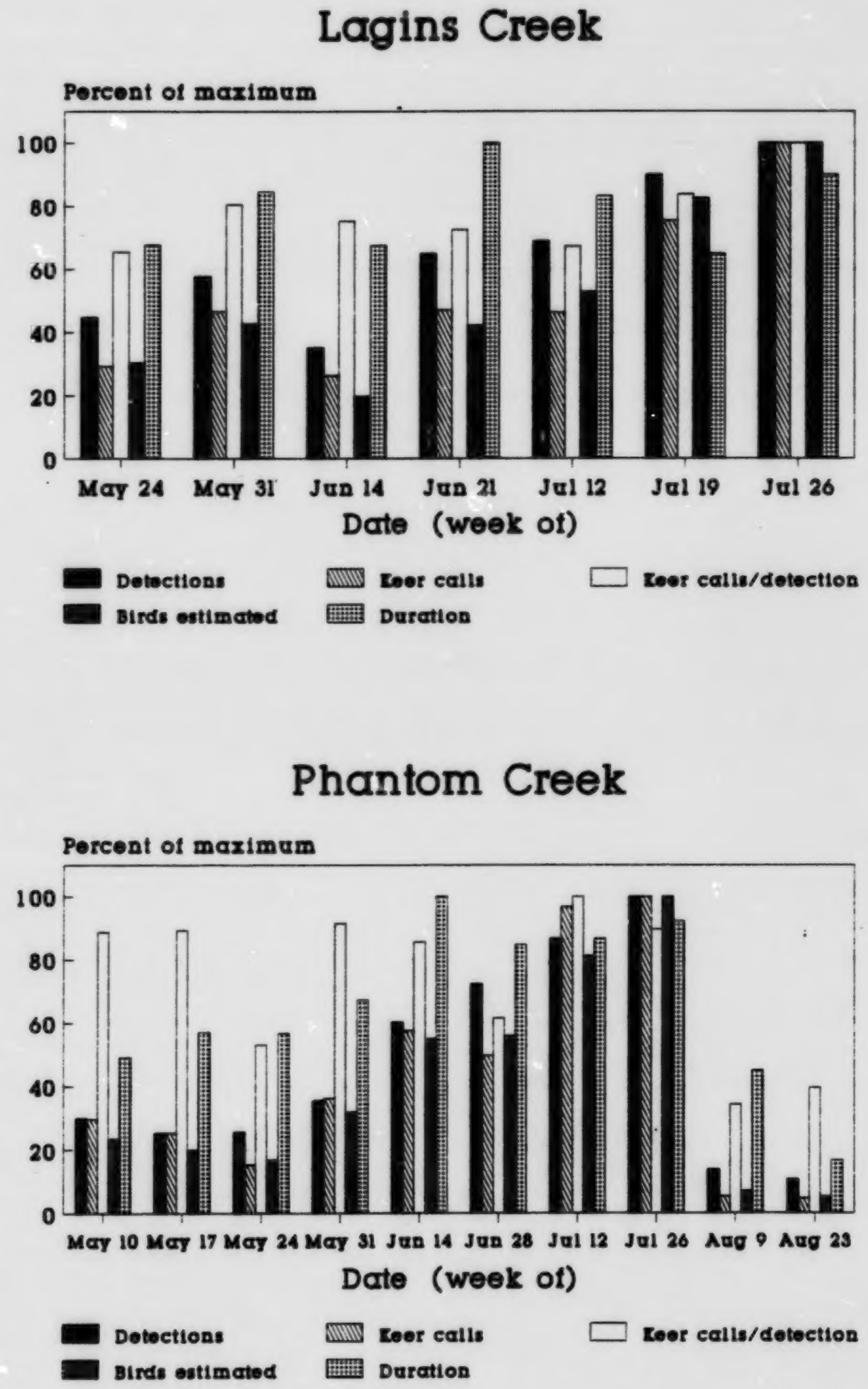
1.2. Seasonal activity patterns:

Over the season, the number of detections per survey were highly correlated with total keer calls ($r = 0.942$; $p < 0.0001$ at Lagins Creek; $r = 0.954$; $p < 0.0001$ at Phantom Creek) and total birds estimated ($r = 0.934$; $p < 0.0001$ at Lagins Creek; $r = 0.985$; $p < 0.0001$ at Phantom Creek). The correlation between number of detections and duration of activity was weaker, especially at Lagins Creek, though still significant at both stations ($r = 0.444$; $p = 0.0097$ at Lagins Creek; $r = 0.761$; $p < 0.0001$ at Phantom Creek). Calls per detection were significantly correlated with number of detections at Lagins Creek ($r = 0.500$; $p = 0.003$) but not at Phantom Creek ($r = 0.139$; $p = 0.379$). Weekly mean numbers of detections, keer calls, keer calls per detection, and birds estimated all peaked during the week of 26 July at Lagins and Phantom creeks, except for keer calls per detection at Phantom

Creek which peaked during the week of 12 July. Weekly mean duration reached a maximum during the week of 21 June at Lagins Creek and 14 June at Phantom Creek (Fig. 4).

1.2.1. Number of detections:

Mean number of detections per week increased from May through July and peaked during the week of 26 July at both monitored stations (Figs. 4-5; Appendices 2-3). The number of detections recorded on concurrent surveys at the two stations were correlated over the entire season ($r = 0.59$; $p = 0.0026$), though at Lagins Creek, mean numbers of detections per week did not increase from May to June, but increased from June to July (Fig. 6), while at Phantom Creek the increase occurred from May to June (Fig. 7). There was considerable variability between the two stations and a lack of correlation on a daily or weekly scale. The average number of detections at Lagins Creek ranged between 27 ± 4 (SE) and 50 ± 13 in May and June and between 54 ± 3 and 78 ± 5 in July. At Phantom Creek, the mean weekly number of detections was similar in May, ranging between 24 ± 4 and 34 ± 4, then increased to 57 ± 10 in the second week of June and steadily through June and July to a peak of 95 ± 22 in late July. The number of detections were slightly more numerous at Lagins Creek than at Phantom Creek in May but not in June or July when they were higher at Phantom Creek. Activity decreased abruptly during the second week of August (13 ± 4 detections).


Lagins Creek

Phantom Creek

Figure 4. Relative seasonal level of Marbled Murrelet forest activity at the two permanent stations.

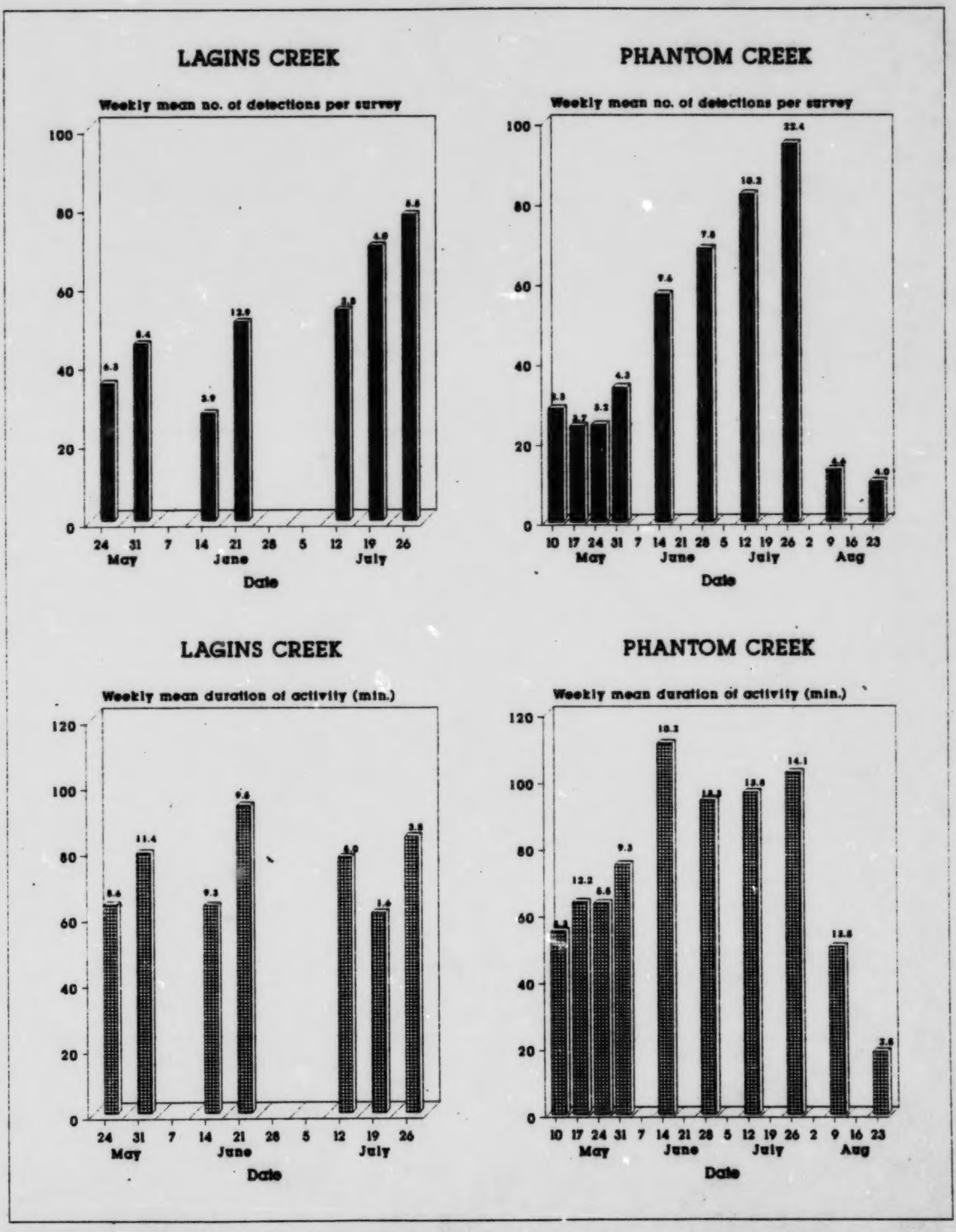


Figure 5. Weekly means of Marbled Murrelet detections and mean activity duration at the two permanent stations. (S.E. shown above bar.)

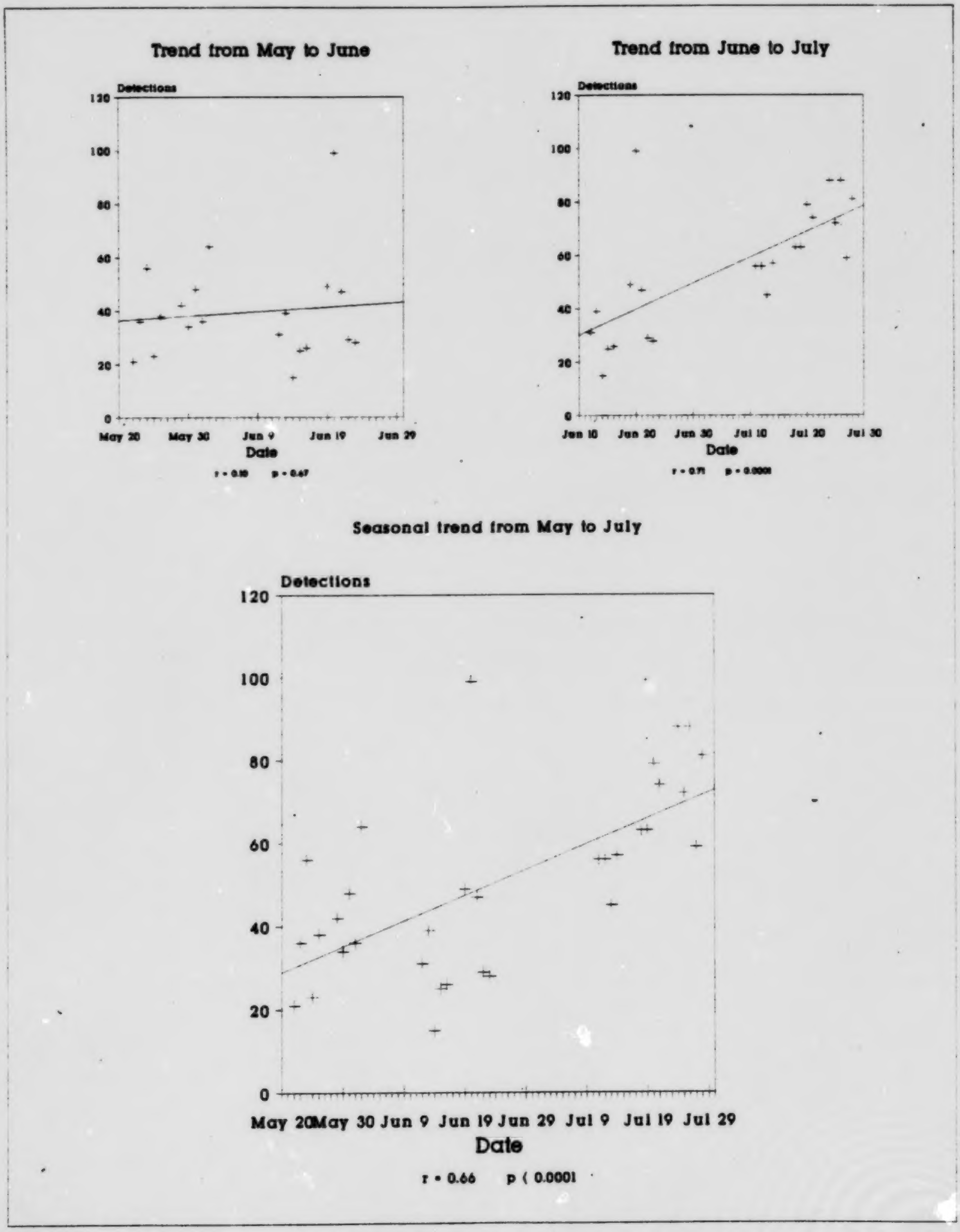
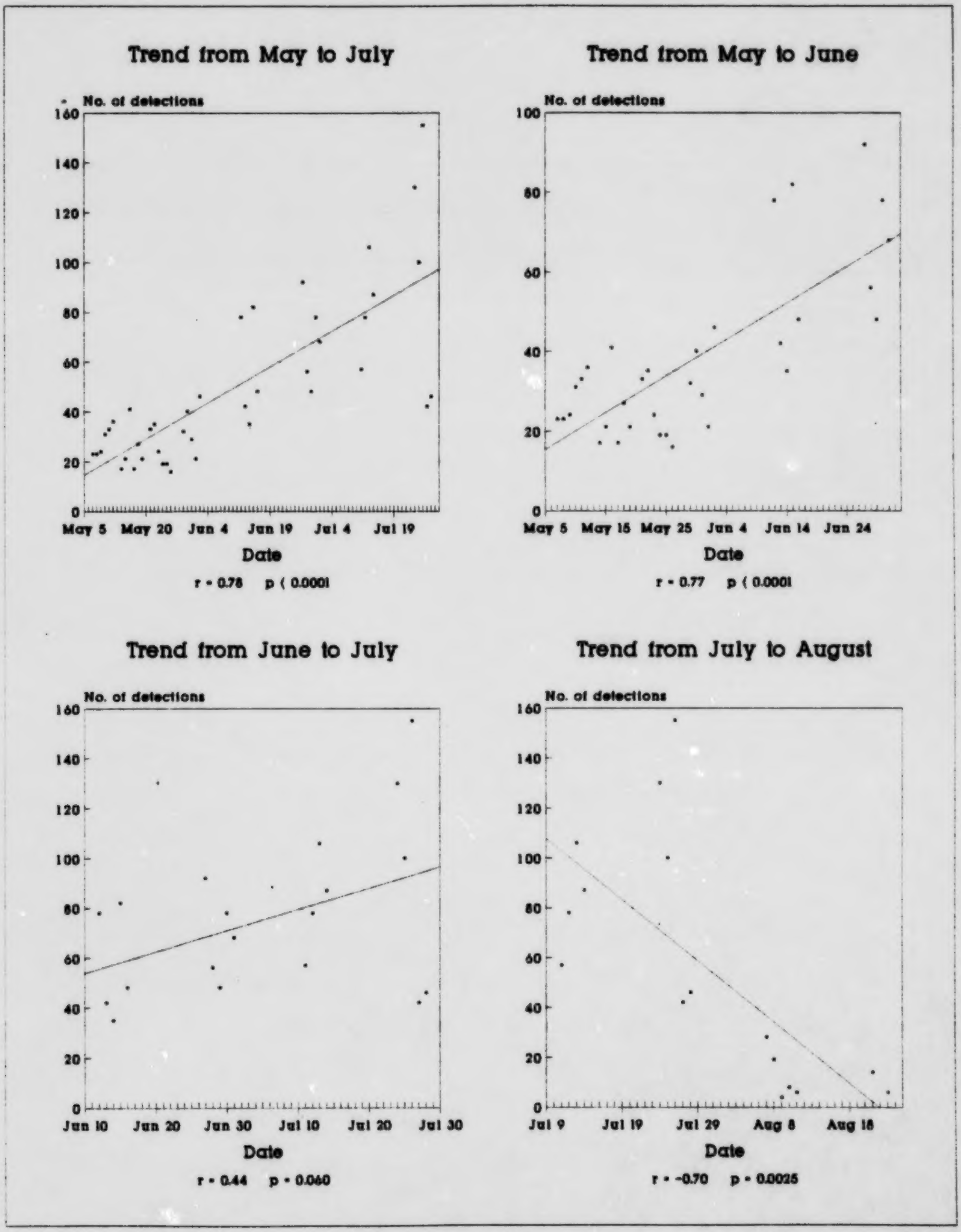


Figure 6. Seasonal trend in the number of detections at Lagins Creek.



Trend from May to July

r = 0.78 p (0.0001

Trend from May to June

r = 0.77 p (0.0001

Trend from June to July

r = 0.44 p = 0.060

Trend from July to August

r = -0.70 p = 0.0025

Figure 7. Seasonal trend in the number of detections at Phantom Creek.

1.2.2. Number of keer calls:

When observers could not count the number of keer calls for a detection, they recorded "M" to indicate >10 calls. To analyse numbers of keer calls, we calculated the mean number of calls >10 that were actually counted and used that mean to replace all entries of "M". Mean values were 24.0 ± 0.9 (n = 201) and 25.6 ± 0.6 (n = 553) at Lagins Creek and Phantom Creek permanent stations over the entire season, and 22.8 ± 3.9 (n = 43) , 26.5 ± 1.9 (n = 45) , and 26.1 ± 1.0 (n = 206) at other stations in Lagins Creek during May, June and July respectively. The average of these was 25.0 which we used as the substitution value.

As noted above, the number of calls was correlated with the number of detections and showed similar seasonal fluctuations (Fig. 4-6; Appendices 2-3). At Lagins Creek, the mean number of calls per week were lowest during the week of 14 June (425), then reached a peak of 1609 in the last week of July. At Phantom Creek, the mean number of calls per week were lowest during the week of 24 May (231), then increased to a peak of 1517 in the last week of July, and dropped to only 80 in the second week of August. (Fig. 8).

1.2.3. Calls per detection: Weekly mean number of calls per detection showed less seasonal change than the number of detections and the number of keer calls (Fig. 8). Mean calls per detection were lowest during the week of 24 May at both Lagins and Phantom creeks (13.5 and 9.6 respectively), and peaked in the week of 26 July at Lagins Creek (20.6) and 12 July at Phantom Creek (17.9;

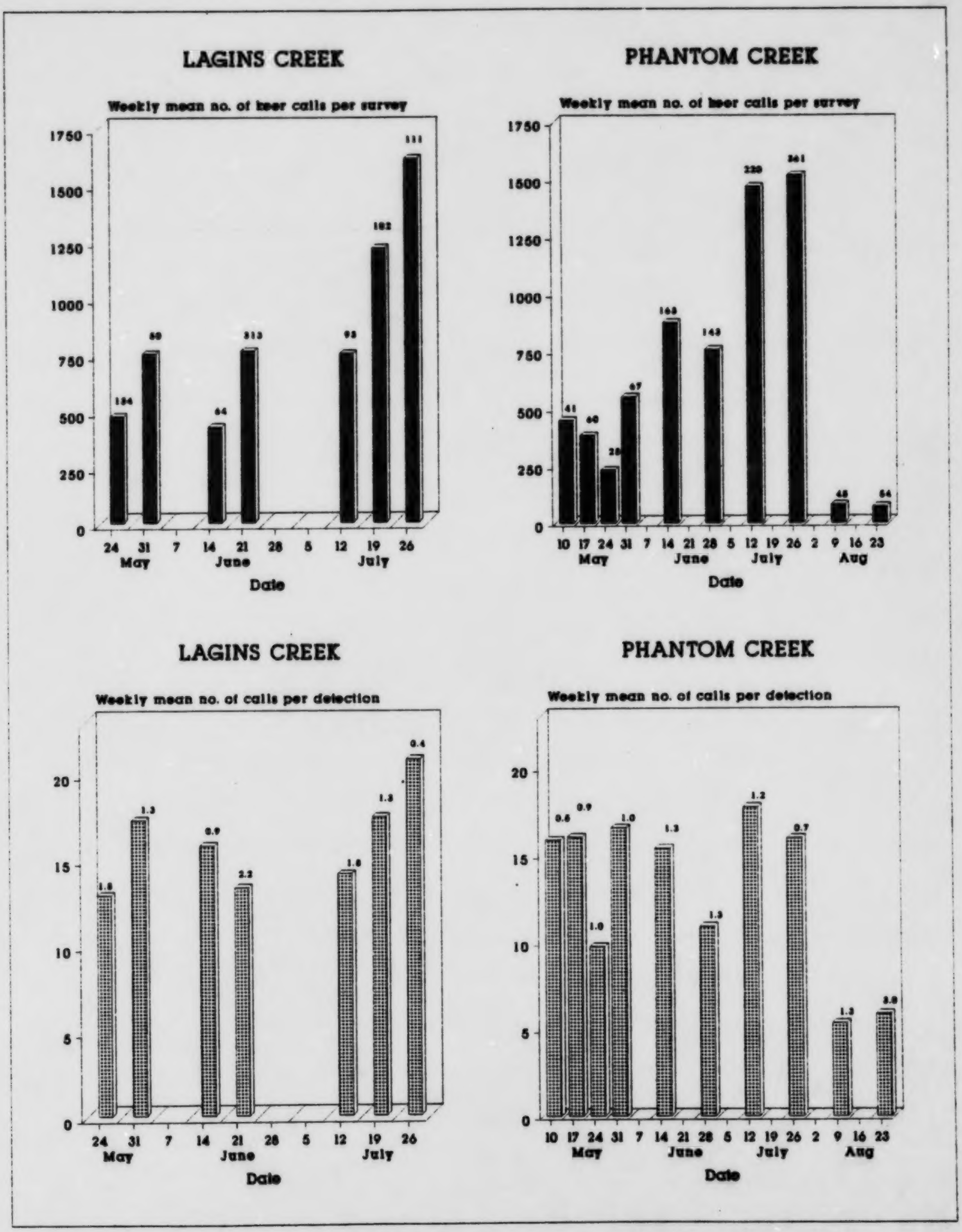


Figure 8. Weekly means of Marbled Murrelet calls per survey and calls per detection at the two permanent stations. (S.E. shown above bar.)

Fig. 8). They increased from May to July at Lagins Creek ($r = 0.391$; $p < 0.05$), but not at Phantom Creek ($r = 0.091$; $p > 0.5$). They dropped sharply and from July to August at Phantom Creek to their lowest value of 7.1 ($r = -0.671$; $p < 0.01$).

1.2.4. Duration of activity:

The length of the Marbled Murrelet morning activity period (from the first to the last detection) ranged between 35 and 127 minutes at Lagins Creek ($n = 33$ days) and between 15 and 154 minutes ($n = 47$ days) at Phantom Creek. A 2-way ANOVA and multiple regression of duration with date and weather (see below) showed no clear seasonal pattern in the length of activity period at Lagins Creek (F-ratio = 1.62; $p = 0.184$; $r = 0.25$; $p = 0.102$), but a significant increase from May to June and July at Phantom Creek (F-ratio = 6.37; $p < 0.0001$; $r = 0.63$; $p < 0.0001$). The duration of activity was similar in both areas in late May, but differed in June and July being longer at Phantom than at Lagins Creek (Fig. 5). As with numbers of detections and calls, the duration of activity dropped considerably in August (Figs. 4-5).

1.3. Comparison of morning and evening detections:

The number of detections recorded on evening surveys was always less than that recorded on morning surveys, though activity in the evening tended to increase in July, especially at Lagins Creek (Table 1). Detections before sunset were rare, most activity occurring from 10 to 45 minutes after sunset.

Table 1. Numbers of Marbled Murrelet detections recorded on evening and following morning surveys at Lagins Creek plot 16 and Phantom Creek plot 12 from May to July, 1990.

Lagins Creek			Phantom Creek		
	No. of detections			No. of detections	
Date	Evening	Following morning	Date	Evening	Following morning
May 22	2	36	Jun 12	1	42
23	6	56	15	1	48
24	3	23	29	4	78
25	0	38	30	15	68
29	14	34	Jul 13	13	87
30	5	48	24	5	100
Jun 15	3	26	27	4	46
18	1	49			
19	4	99			
Jul 11	21	56			
12	16	45			
13	27	57			
18	30	63			
19	57	79			
20	38	74			
24	31	72			
25	24	88			
26	40	59			
27	37	81			

1.4. Effect of weather on murrelet activity:

Weather influenced the daily variability of activity levels. Fog and cloud tended to be more frequent at the Phantom Creek station (62% of survey days with fog or ≥ 80% cloud) than at Lagins Creek (55% of survey days with fog or ≥ 80% cloud), but overall weather patterns at the two stations were significantly correlated ($r = 0.51$; $p = 0.011$). The mean number of detections per survey was higher on foggy and cloudy days than on clear days, though differences were significant only at Phantom Creek (Table 2). Activity also started later and lasted longer in foggy or cloudy weather (Fig. 9). At Lagins Creek, 80% of detections occurred within 47 to 0.5 minutes before sunrise on clear days (median = 25 minutes before sunrise), and 35 minutes before to 30 minutes after sunrise on foggy and cloudy days (median = 5 minutes before sunrise). The range of times varied from month to month (Fig. 10; Appendix 4), but differences in mean detection times relative to sunrise on clear and cloudy days existed during all months ($p < 0.0001$ at both stations; Appendix 4). The mean duration of activity was longer on cloudy and foggy days than on clear days at both stations, though at Phantom Creek the average difference (34.6 minutes) was nearly twice as long as at Lagins Creek (18.2 minutes; Table 3).

2. Behaviour and group size:

2.1. Visual vs auditory detections:

To analyse behaviour and group sizes, we included only birds that were seen, as the behaviour of those that were only heard could only be estimated. During May and most of June at Lagins Creek, birds were not seen due to an inability of the observer to spot flying birds, and those months were excluded from analyses of flight behaviour. Most detections were auditory, but birds were seen in 18.7% (165 of 881) of detections at Lagins Creek in July and 25.6% (549 of 2142) of detections at Phantom Creek from May to August. The greater visiblity at Phantom Creek probably accounted

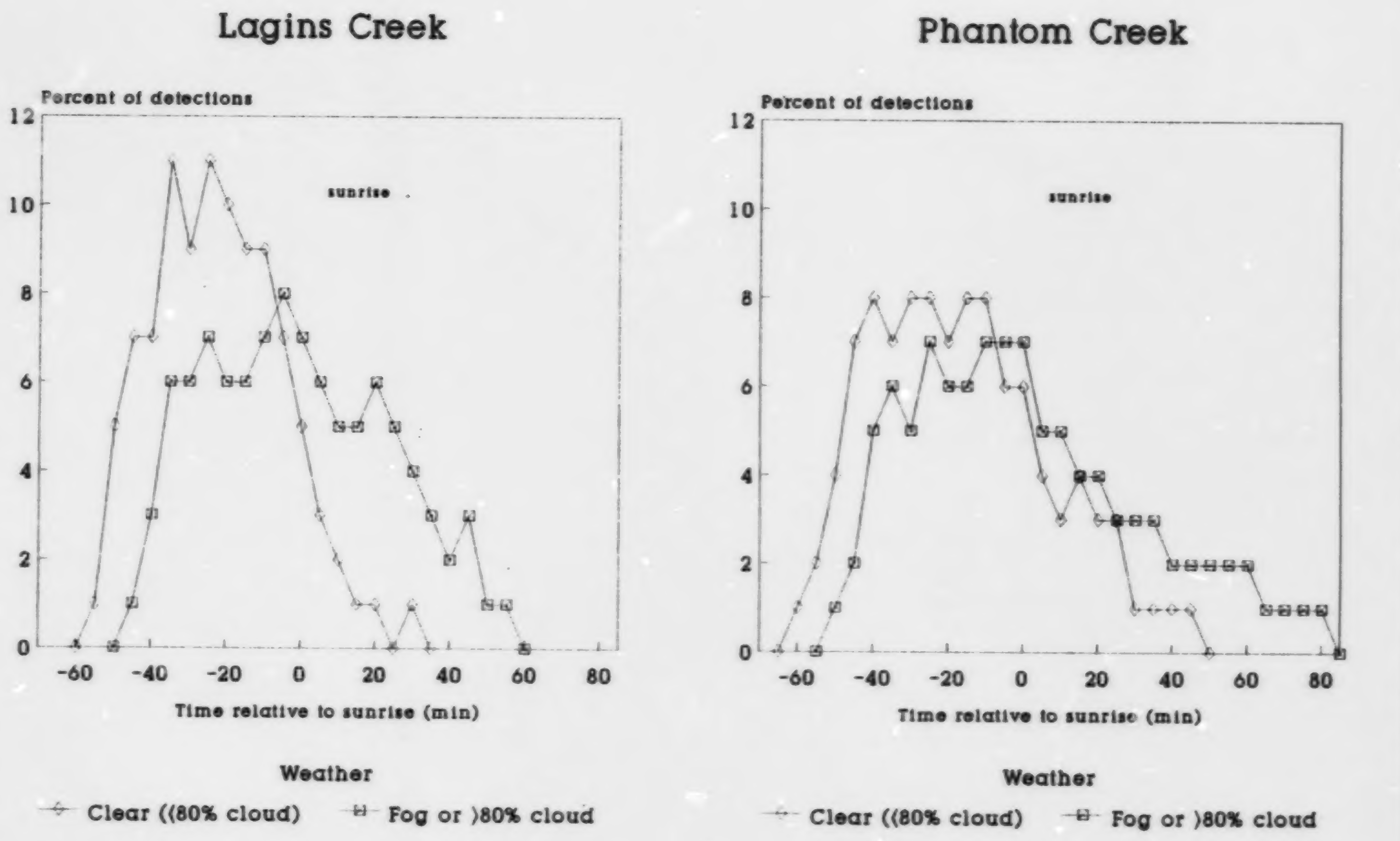


Figure 9. Marbled Murrelet detections in relation to sunrise and weather at Lagins and Phantom creeks.

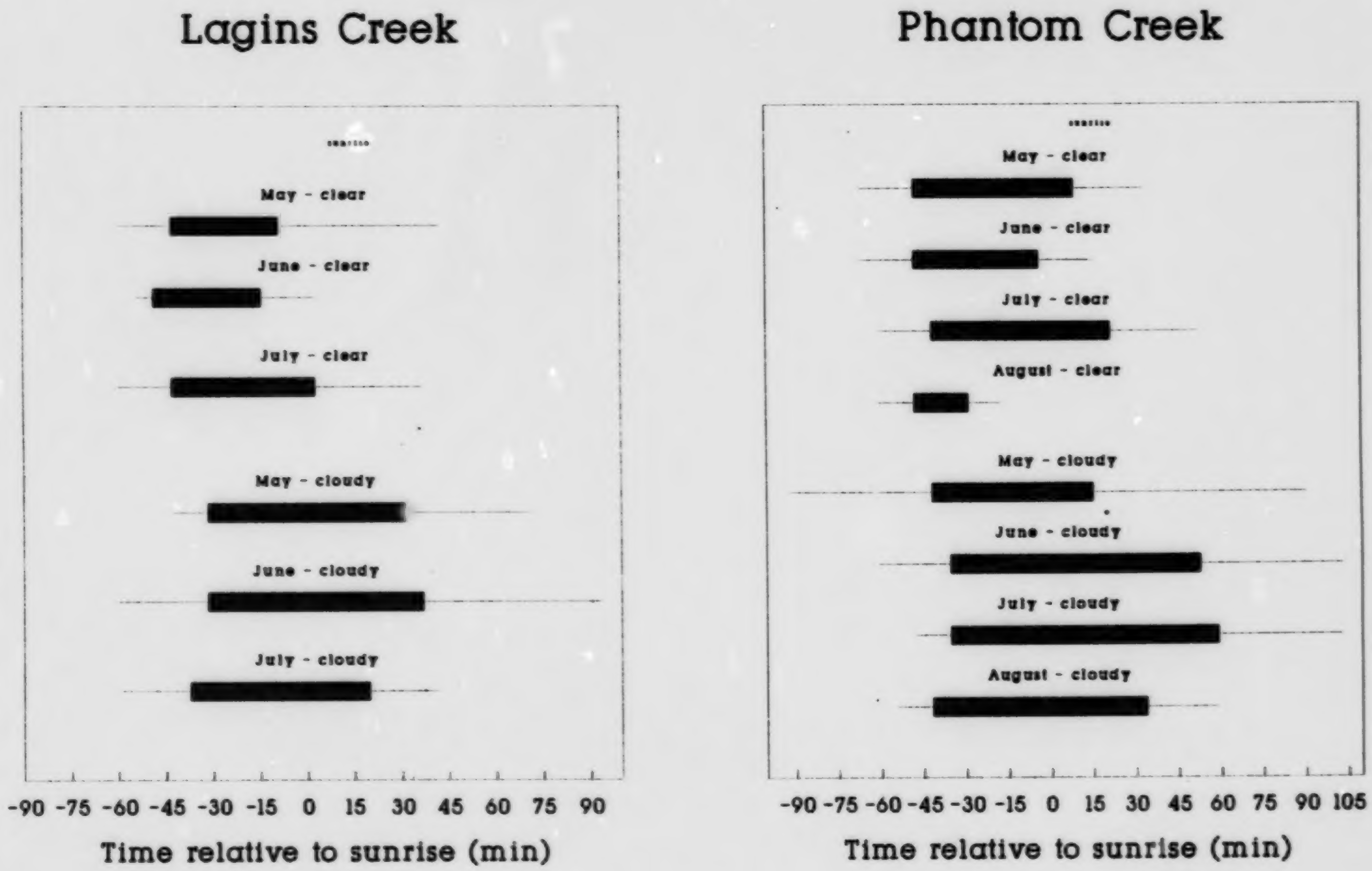


Figure 10. Seasonal variation in Marbled Murrelet detections in relation to sunrise and weather at Lagins and Phantom creeks. (Line = range, dark bar = 80% of observations i.e. 10-90 percentiles.)

Table 2. Mean number of Marbled Murrelet detections per survey in foggy/cloudy (fog or ≥80% cloud) and clear (<80% cloud) weather during May, June and July. Means are weighted from a 2-way ANOVA of number of detections with date and weather, and take account of seasonal increases in detection rates.

	Fog/cloud	Clear	Comparison	
	Mean ± SE	Mean ± SE	F-ratio	p
Lagins Creek	55.6 ± 3.5	46.1 ± 3.8	2.31	0.141
Phantom Creek	58.3 ± 3.9	40.8 ± 5.0	5.74	0.022

Table 3. Mean duration (minutes) of Marbled Murrelet activity per survey in foggy/cloudy (fog or ≥80% cloud) and clear (<80% cloud) weather during May, June and July. Means are weighted from a 2-way ANOVA of duration of activity with date and weather, and take account of seasonal increases in duration.

	Fog/cloud	Clear	Comparison	
	Mean ± SE	Mean ± SE	F-ratio	p
Lagins Creek	82.5 ± 3.8	64.7 ± 4.1	6.86	0.015
Phantom Creek	95.7 ± 4.6	61.1 ± 5.9	16.55	0.003

for the larger number of visual detections. Birds were calling in 45.5 and 50.3% of visual detections at Lagins and Phantom creeks respectively, and were silent in the rest.

2.2. Group size:

Group size of sighted Marbled Murrelet flocks ranged from 1 to 7 birds. Single birds were the most frequent flock size seen at Phantom Creek in May and June, and groups of two were most prevalent in July at both Lagins and Phantom creeks (Fig. 11). The

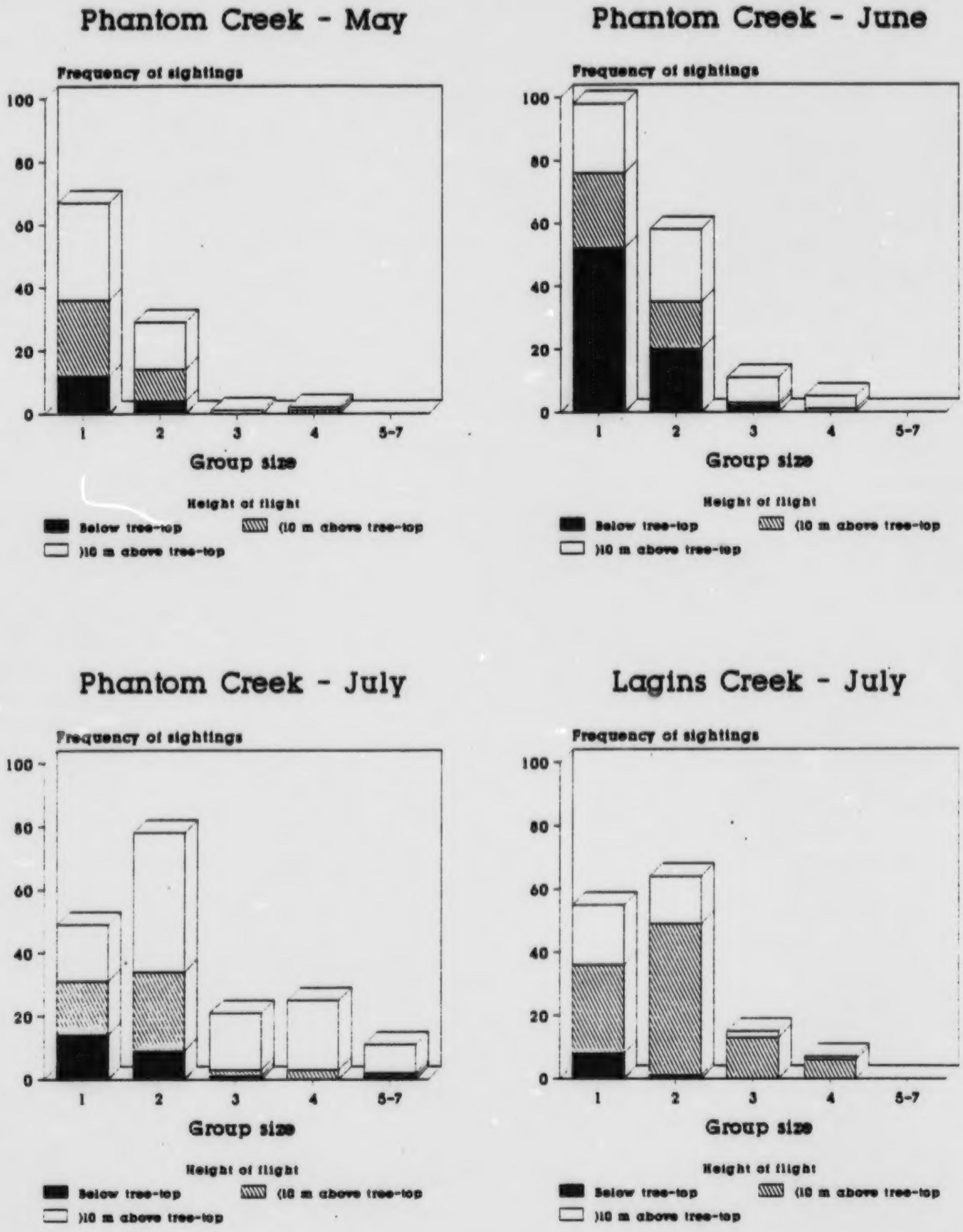


Figure 11. Frequency of Marbled Murrelet sightings in relation to group size.

average frequency of flocks of more than 2 birds increased from May through July at Phantom Creek ($T = 68.45$; $p < 0.0001$).

The majority of single birds sighted were silent in all months and at both stations (Fig. 12). The same was true for pairs except in May at Phantom Creek when more pairs were calling than were silent. All larger flocks sighted were calling, except for one detection of three silent birds at Lagins Creek. Overall, the proportion of calling birds increased with increasing flock size at both Phantom Creek ($X^2 = 163.8$, $P < 0.0001$) and at Lagins Creek ($X^2 = 31.9$, $P < 0.0001$ at Lagins Creek).

2.3. Height of flight:

At Lagins Creek in July, 26.2% of visual detections were >10 m above tree-top, 67.4% were <10 m above tree-top, and 6.4% were below tree-top level ($n = 141$). At Phantom Creek, the overall proportions from May to August were 48.2, 26.9, and 24.9% respectively ($n = 461$). Those proportions changed through the season, with the greatest proportion of birds flying below tree-top (42.8% of detections) occurring in June, and the largest proportion of birds flying >10 m above tree-top (57.2% of detections) recorded in July (Fig. 13; Appendix 5).

Greater proportions of small flocks than large flocks were sighted below tree-top in all months at Phantom Creek ($X^2 = 63.4$; $p < 0.0001$) and in July at Lagins Creek ($X^2 = 16.4$; $p = 0.011$). In June at Phantom Creek, 53.1% of single birds sighted were flying below tree-top level (Fig. 11).

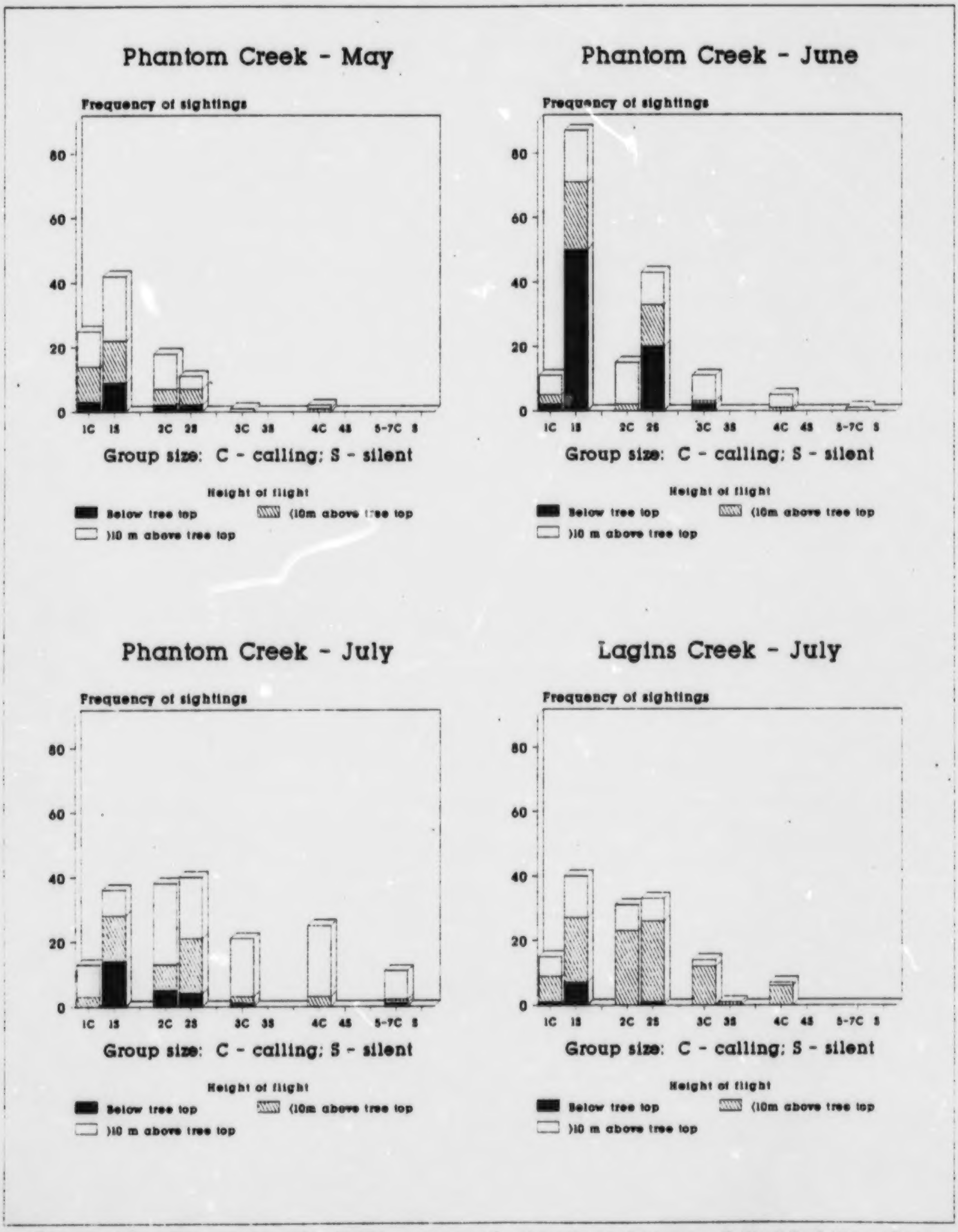
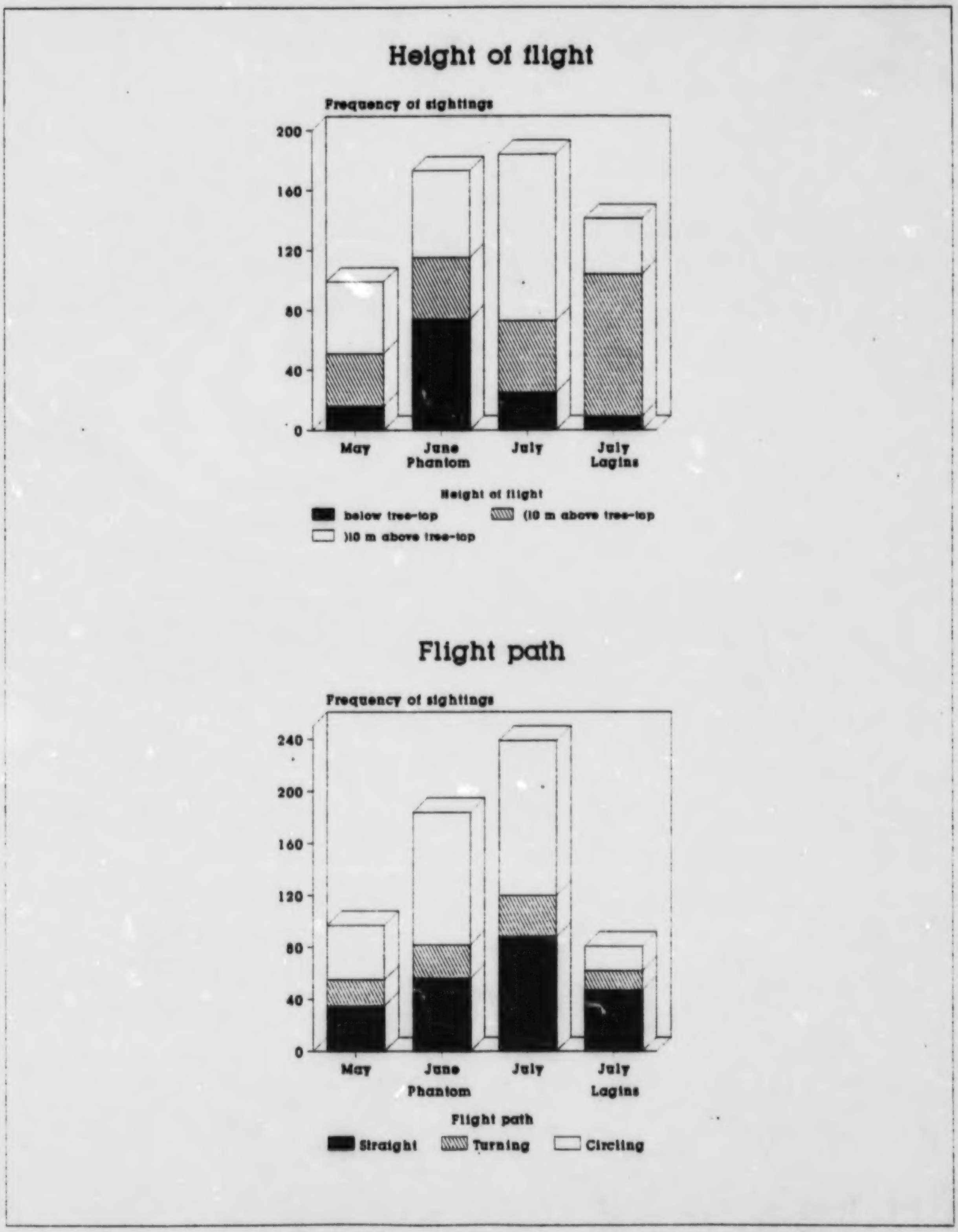


Figure 12. Frequency of silent and vocal visual sightings of Marbled Murrelets in relation to group size and flying altitude.



Height of flight

Flight path

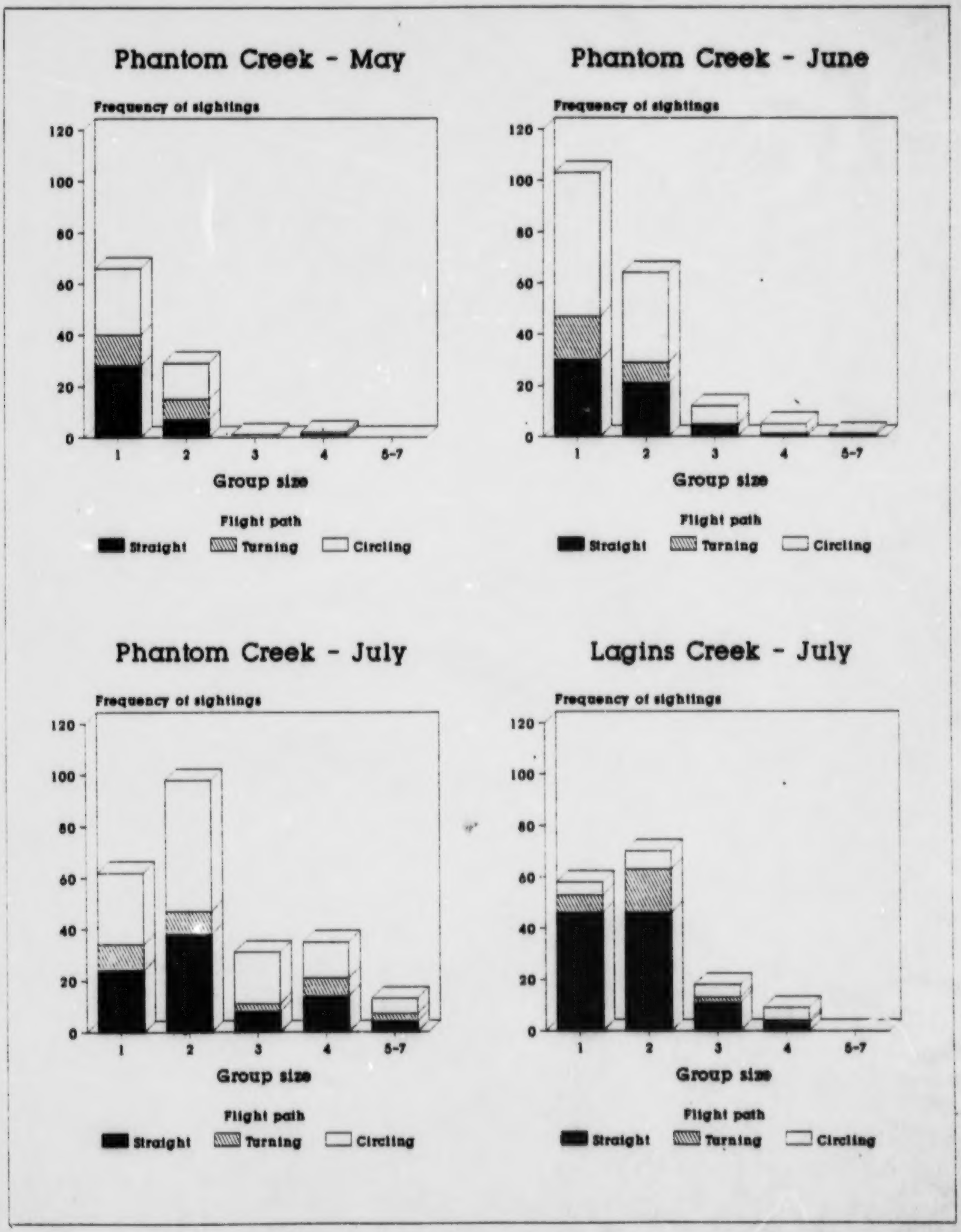
Figure 13. Seasonal frequency of Marbled Murrelet sightings in relation to flying altitude.

Most birds (86.1% at Phantom Creek and 88.9% at Lagins Creek) flying below tree-top were silent (Fig. 12). The ratios of silent to calling birds were larger in flocks flying below tree-top (99:16 - 86.0% silent) and <10 m above tree-top (83:41 - 66.9% silent) than in flocks flying >10 m above tree-top (78:144 - 35.1% silent) at Phantom Creek ($X^2 = 87.6$, $p < 0.0001$). At Lagins Creek, the proportions of silent and calling birds were similar at <10 m (46:49 - 48.4% silent) and >10 m (17:20 - 45.9% silent) above tree-top ($X^2 = 0.34$; $p = 0.561$), but differed below tree-top (8:1 - 88.9% silent; $X^2 = 5.39$; $p = 0.020$).

2.4. Flight path:

The proportions of straight, turning, and circling flight behaviour were similar in May, June, and July at Phantom Creek (Fig. 13; Appendix 6). Overall proportions from May to July were 34.3% straight, 15.2% turning, and 50.5% circling. A greater percentage of straight flight (68.4%) than turning (17.4%) or circling (14.2%) was recorded at Lagins Creek in July. This was likely due to the more limited visibility at Lagins Creek, which made it more difficult to observe circling behaviour than at Phantom Creek.

There were no clear differences in the types of flight paths observed for different group sizes (Fig. 14) or for silent and calling birds (Fig. 15). However, at Phantom Creek in June, there was a tendency for calling pairs to circle more than silent pairs. This difference was not seen in May or July.



Phantom Creek - May

Phantom Creek - June

Phantom Creek - July

Lagins Creek - July

Figure 14. Frequency of Marbled Murrelet sightings in relation to group size and flight patterns.

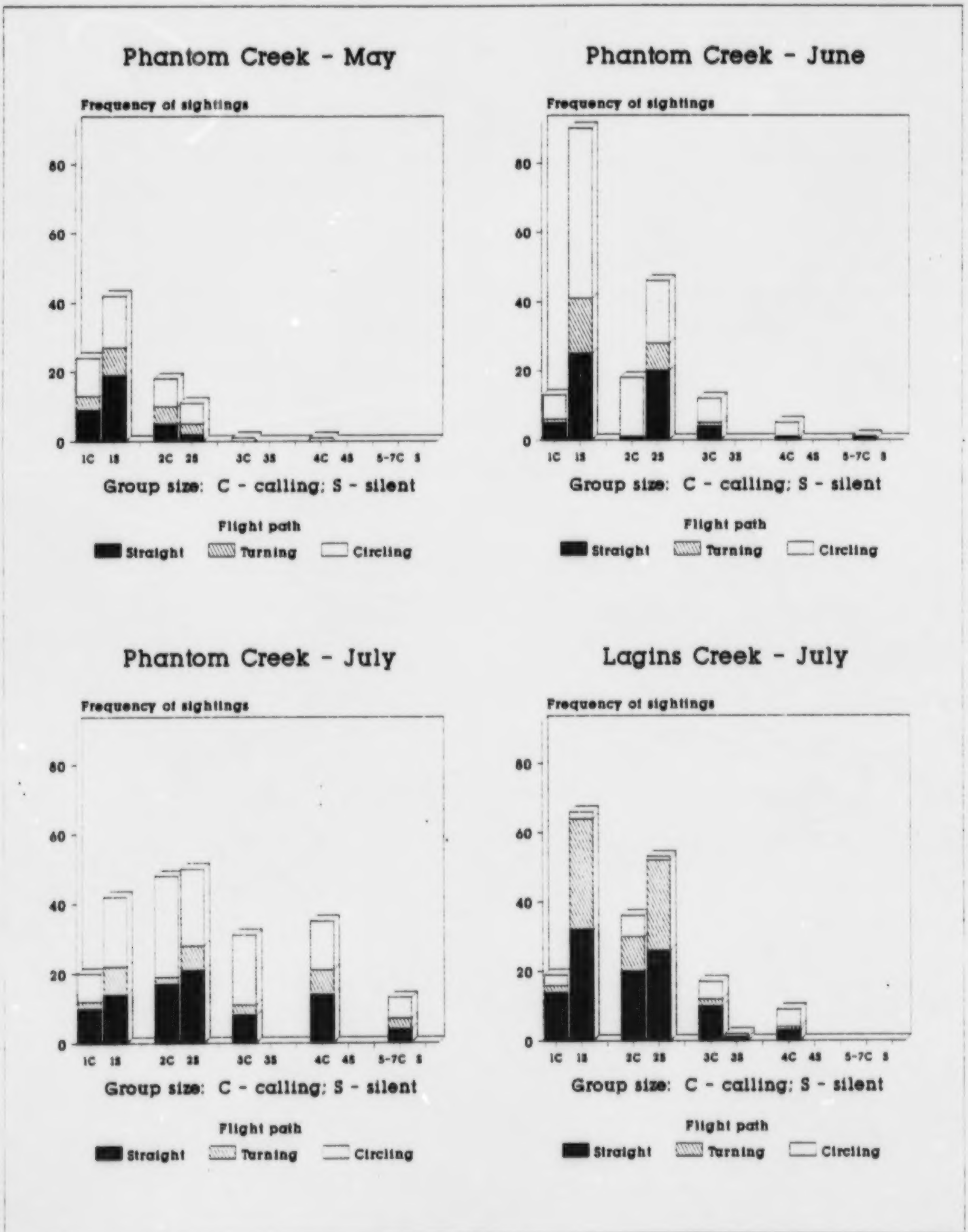


Figure 15. Frequency of silent and vocal visual sightings of Marbled Murrelets in relation to group size and flying patterns.

3. At-sea activity patterns:

3.1. Seasonal abundance and distribution in Long Inlet:

The abundance of Marbled Murrelets varied both daily and seasonally in the Inlet (Appendix 7). Counts ranged from a maximum of 117 on 18 May to a minimum of 13 on 13 June during the intensive survey period. The highest count of 147 murrelets was recorded on a preliminary survey on 11 May (see Geographical distribution). Weekly averages decreased from 47 birds in mid May to 9 birds in the second week of June, then increased again from late June (29 birds) to an average of 51 birds in late July. Numbers were generally highest in the morning, declined during the day, then rose to a lower peak in the evening (Appendix 7).

Marbled Murrelets were not uniformly distributed in Long Inlet. They tended to be more abundant near the mouth of the inlet in mid-May and more abundant at the head of the inlet in June and July (Appendix 8). Murrelets were uncommon along the southwest side of the inlet, most birds gathering through the centre and northeast sides of the inlet. Large flocks were most frequent in the centre of the inlet.

3.2. Seasonal abundance in Shields Bay:

Fewer Marbled Murrelets were seen in Shields Bay in June and July than in May (Appendix 9). A maximum of 29 were counted on 30 May, but even in May there were <10 birds counted on most surveys. On many surveys, especially during the middle of the day, there were no birds present in the bay. Numbers tended to be highest in the evening. Counts of up to 65 birds done prior to the scheduled survey period suggested a larger population of Marbled Murrelets using the bay in early May (Appendix 9). Birds sighted in Shields Bay were often flying, either to or from the north or northwest. Subsequent surveys conducted outside the study area indicated that murrelets were more frequent to the northwest in Rennell Sound (see Geographical distribution).

3.3. Group size:

A large proportion of birds in Long Inlet and Shields Bay were either single or paired in all months. The number of single birds was highest in the third week of May (average = 12 ± 5). They decreased in late May and remained low thereafter. The number of pairs in the inlet averaged 16 ± 2 and 15 ± 3 in the second week and last weeks of May, dropped to 3 ± 1 and 11 ± 3 in mid June and late June, then peaked at 20 ± 2 and 21 ± 2 pairs in the second and fourth weeks of July (Appendix 10). The frequency of birds in groups larger than two was highest in the third week of May, decreased in late May and early June, then increased again in late June and July. In Shields Bay, single birds were most abundant in the second and last weeks of June. Pairs and larger groups were most frequent in May (Fig. 16; Appendix 10).

The ratio of the number of single birds to the number of pairs in Long Inlet dropped from 37.0 ± 10.0 in the third week of May to only 15.5 ± 3.2 in the following week, rose to a maximum of 48.0 ± 6.7 in mid-June, then decreased thereafter to 19.0 ± 1.6 in late July. In Shields Bay, the ratio of single birds to pairs was also highest in mid-June (Fig. 17; Appendix 10).

3.4. Plumage and breeding chronology:

Most birds seen in Long Inlet throughout the survey period were in breeding plumage, but a few individuals still moulting into breeding plumage were present in the inlet until 30 May. The first juveniles (3) were seen on 12 June, single juveniles were recorded on 15, 28 and 29 June, and 1, 11, 13 and 24 July, and two were observed on 26 July. Single adults in basic plumage were seen on 30 June, and 1, 12, 24, 25 and 27 July. Birds holding fish were first sighted a month after the first juveniles appeared on the inlet. All but one sighting of birds with fish occurred in the evening:. single birds with fish were recorded on 11 (0930 h), 13 (1705 h), 24 (1740 h, 1940 h (2), 1950 h), 25 (1730 h), 26 (flying into the inlet at 1930 h), and 27 July (1730 h, 1940 h - with at least two fish).

The first sighting in Shields Bay of a bird with fish in its bill was on 12 June (2105 h); two with fish were seen at 2000 h on 13 June and 2006 h on 14 June, and single birds holding fish were

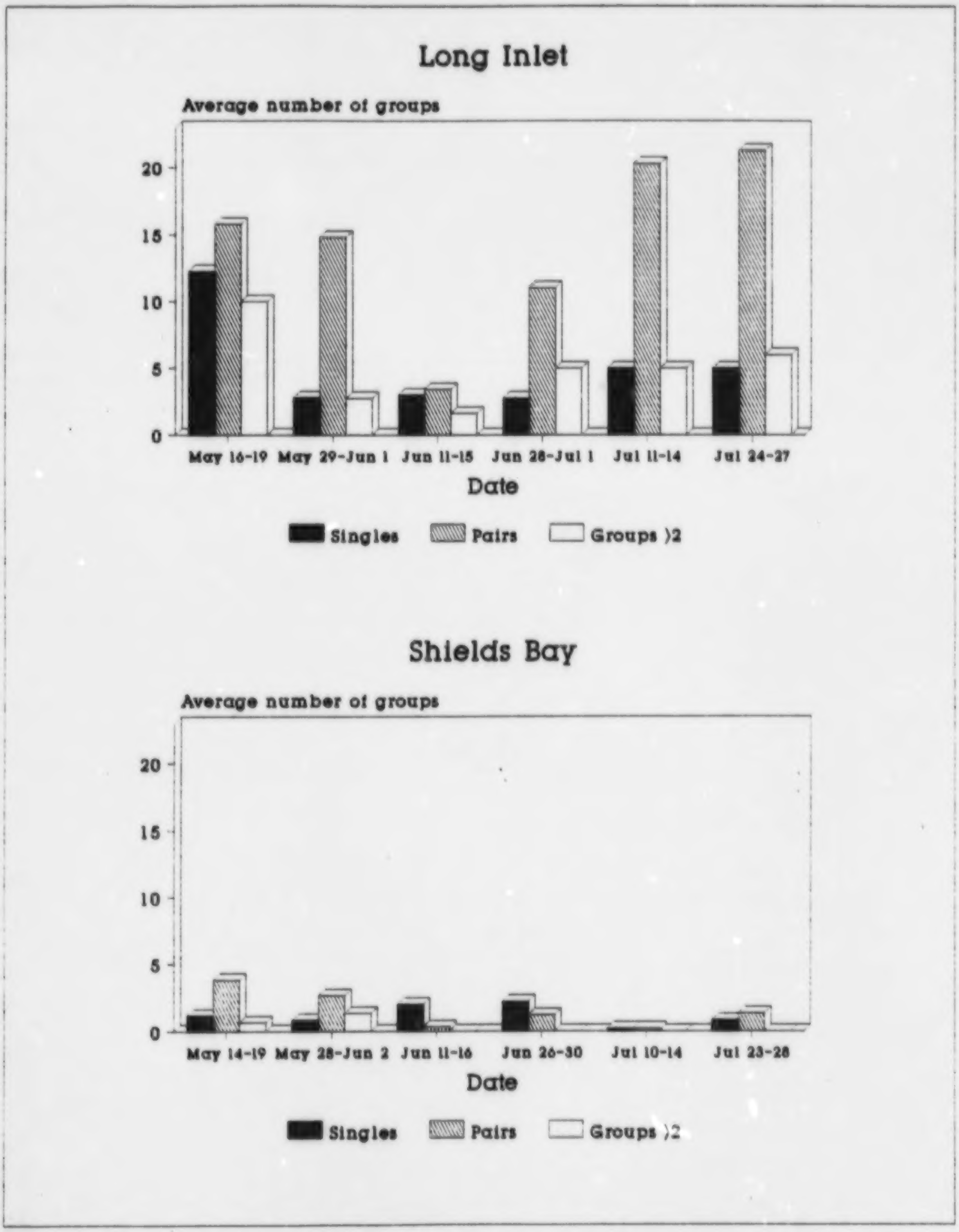


Figure 16. Seasonal variations in Marbled Murrelet group sizes in Long Inlet and Shields Bay.

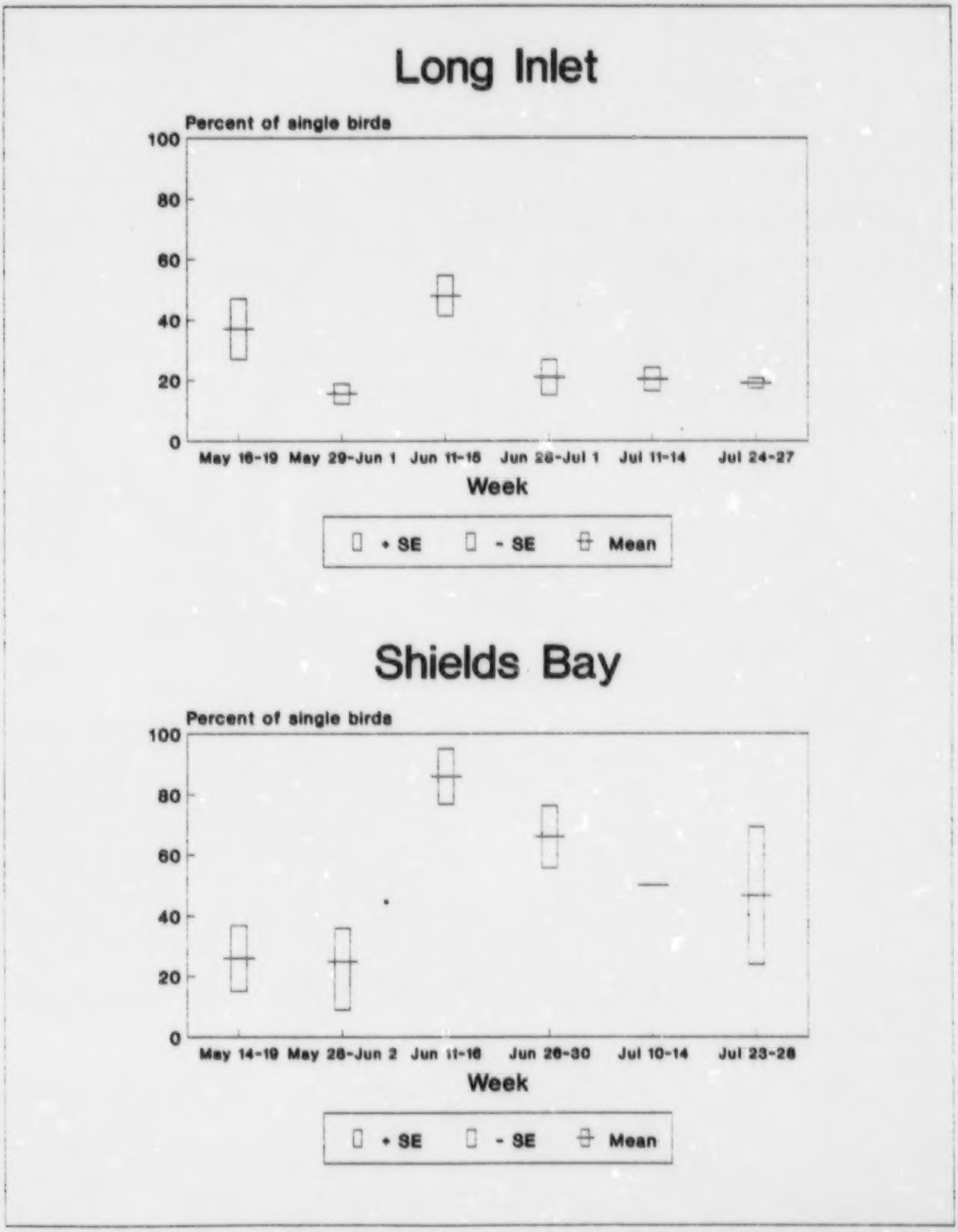


Figure 17. Relative frequency of single and paired Marbled Murrelets in Long Inlet and Shields Bay.

recorded at 1900 h on 26 June and 2000 h on 10 July. Suspected juveniles were sighted on 26 and 27 July, and adults in basic plumage were seen on 27 July (Appendix 9).

3.5. Relation to inland activity levels:

The level of murrelet morning activity at the permanent inland station in Lagins Creek reflected the abundance of murrelets in Long Inlet (Table 4), with a peak in late July and a low in the second week of June.

Table 4. Relationship between the number of Marbled Murrelets in Long Inlet and the level of murrelet activity in the forest at Lagins Creek station 16.

Date	Mean no. of birds on water	Maximum no. of birds on water	Mean no. of detections	Mean no. of calls
May 29-June 1	25.1 ± 4.6	53.8 ± 15.5	44.8 ± 5.4	748.4 ± 49.8
June 11-June 15	9.1 ± 1.4	18.5 ± 4.6	27.2 ± 3.9	425.0 ± 64.5
July 11-July 14	48.2 ± 4.1	69.8 ± 5.1	53.5 ± 2.8	746.3 ± 93.2
July 24-July 27	51.1 ± 3.4	70.5 ± 7.3	77.6 ± 5.5	1609.2 ± 111.0

4. Marbled Murrelet activity in relation to habitat type:

4.1. Habitat types:

Low and high elevation forest sampled in Lagins Creek lie in the Wet Hypermaritime Coastal Western Hemlock biogeoclimatic subzone (Banner et al. 1990). We identified six site associations within that subzone in the Lagins Creek study area (Table 5). From plots surveyed within four of those subzones, we developed a classification of seven vegetation groups (Appendix 11). Site associations of Western Redcedar/Western Hemlock-Blueberry (Vaccinium spp. - CwSs-B) and Lodgepole Pine (Pinus contorta)/ Yellow Cedar-Sphagnum spp. (PlYc- S) were not sampled by vegetation plots and were not included in the vegetation classification. The seven vegetation groups fell into two major alliances discriminated primarily by the presence (groups 1-4) or absence (groups 5-7) of Yellow Cedar. The first alliance (groups 1-4) was associated primarily with higher elevation, except for wetter areas in the low-elevation forest. Within the second alliance (groups 5-7), Sitka Spruce occurred only within groups 6 and 7. Group 6 corresponded to the Western Hemlock/Sitka Spruce-Rhytidiadelphus loreus (CwSs-L) site association, and in the Lagins Creek study area was identified only on side slopes at higher elevations (300 m) in the vicinity of Marbled Murrelet stations 22 and 26 (Fig. 2). At Phantom Creek, this site association did occur in the valley bottom around Marbled Murrelet station 5, though at a similar elevation (260 m) as at Lagins Creek. Group 7 encompassed site associations redcedar/spruce-foamflower (Tiarella unifoliata

Table 5. Mean dbh of trees within site associations and vegetation groups in Lagins Creek study area.

Site association	Mean dbh (cm)	SD	N
Western Redcedar/Sitka Spruce-Foamflower (CwSs-F)	161.7 A[1]	39.0	28
Western Redcedar/Sitka Spruce-Conocephalum (CwSs-C)	104.0 B	33.3	32
Western Hemlock/Sitka Spruce-Lanky moss (HwSs-L)	93.1 B	19.9	20
Western Redcedar/Sitka Spruce-Skunk Cabbage (CwSs-Sk)	40.4 C	34.8	99
Western Redcedar/Western Hemlock-Blueberry (CwHw-B)	not measured		
Lodgepole Pine/Yellow Cedar-Sphagnum (PlYc-S)	not measured		

[1] Different letters indicate significant differences at the 0.001 level.

Vegetation group	Mean dbh (cm)	SD	N
1	26.0 A[1]	20.2	34
2	89.8 B	35.6	10
3	46.6 A	34.5	65
4	90.2 B	35.7	9
5	100.7 B	19.6	10
6	111.2 B	35.5	21
7	141.2 C	48.8	38

[1] Different letters indicate significant differences at the 0.05 level.

- CwSs-F) and redcedar/spruce-Conocephalum conicum (CwSs- C), and included most low elevation Marbled Murrelet plots except for those falling in wetter areas, identified with site associations redcedar/spruce- Skunk Cabbage (Lysichiton kamtschatcense - CwSs-Sk) and PlYc-S. Largest trees occurred within vegetation groups 6 and 7, and corresponding site associations HwSs-L, CwSs-F, and CwSs-C. Mean dbh in vegetation group 7 was significantly larger than in all other groups (Table 5; Appendix 12).

4.2. Marbled Murrelet activity:

Because of the high correlations between numbers of detections and other parameters, we used only the number of detections as the measure of Marbled Murrelet activity in different habitats.

4.2.1. Old-growth forest and alpine habitat:

Marbled Murrelet activity levels in all months were highest over low-elevation old-growth forest habitat except in June when the number of detections in low and high elevation old-growth did not differ significantly (Table 6; Fig. 18; Appendix 13). The mean numbers of detections per survey recorded from May to July at low, high and alpine stations were 34.2 ± 4.1 (SE), 17.5 ± 3.0, and 3.0 ± 0.7 respectively. Detections in alpine habitat were infrequent, mostly of birds calling from below over low-elevation forest. There were four detections in June and July of birds flying over alpine areas in the vicinity of stations 32 and 33. Those birds appeared to be flying directly over alpine passes to and from

Rennell Sound. Murrelets could be heard at much greater distances at alpine stations than in forested areas. Detections in old-growth forest at high elevation were more frequent than in alpine habitat, and were predominantly of birds flying over low-elevation forest.

Table 6. Kruskal-Wallis test results for comparisons of numbers of Marbled Murrelet detections in old-growth forest at low elevation, old-growth forest at high elevation, and alpine habitat at Lagins Creek.

Month	Habitats compared	T	p
May	Low vs High	4.480	0.0343
	High vs Alpine	8.470	0.0036
	Low vs Alpine	12.623	0.0004
June	Low vs High	0.133	0.7153
	High vs Alpine	8.148	0.0043
	Low vs Alpine	8.817	0.0030
July	Low vs High	6.827	0.0090
	High vs Alpine	9.481	0.0021
	Low vs Alpine	12.632	0.0004
All months	Low vs High	9.001	0.0027
	High vs Alpine	25.983	0.0000
	Low vs Alpine	35.486	0.0000

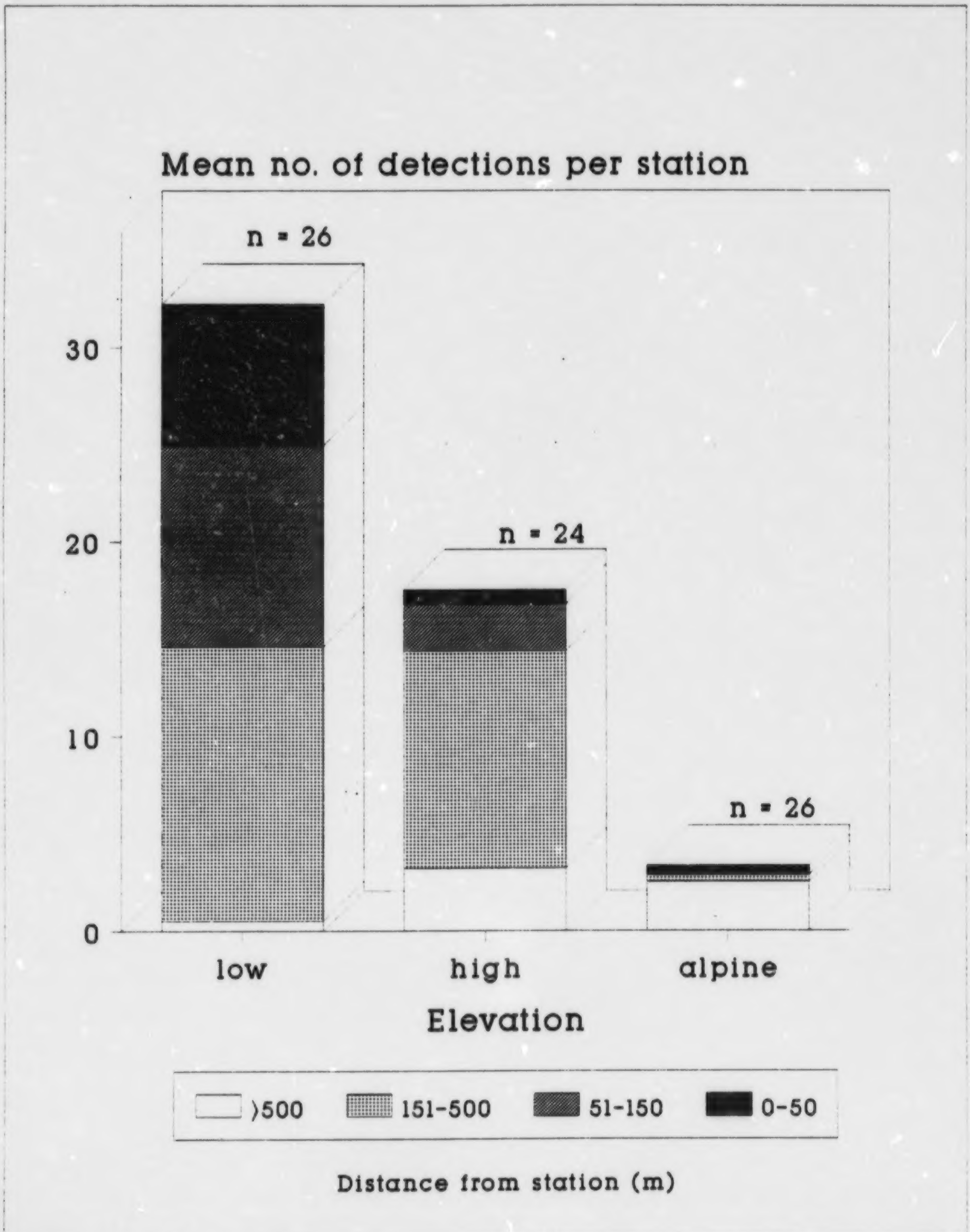


Figure 18. Mean number of Marbled Murrelet detections in low elevation and high elevation old-growth forests and in alpine habitats.

Differences in the mean number of detections per station in each habitat type were more pronounced when only local detections were considered (Fig. 18). Most detections (84%) at alpine stations were of birds 500-1500 m away, while 98% of detections at low elevation stations were within 500 m. Proportions of detections within closer radii of survey stations were significantly higher at low elevation stations than at high elevation and alpine stations: 53.6 ± 5.2% of detections occurred within 150 m of survey stations at low elevations, compared to 17.8 ± 6.7% and 5.1 ± 2.9% at high elevation and alpine stations (Table 7). We found no evidence of activity in alpine areas during searches for nest sites.

Table 7. Results of z tests for comparisons of proportions of Marbled Murrelet detections occurring within 500, 150, and 50 m radii of survey stations in low elevation forest, high elevation forest, and alpine habitat at Lagins Creek from May through July.

	Proportion (± SE) within radii		
Habitat	500 m	150 m	50 m
Low	0.981 ± 0.008	0.536 ± 0.052	0.204 ± 0.033
High	0.815 ± 0.052	0.178 ± 0.067	0.043 ± 0.012
Alpine	0.165 ± 0.055	0.051 ± 0.029	0.051 ± 0.029

Habitats compared	Radius (m)	z	p
Low vs High	500	3.125	0.0009
	150	4.140	<0.0001
	50	4.604	<0.0001
High vs Alpine	500	8.527	<0.0001
	150	1.706	0.0392
	50	-0.250	0.4013
Low vs Alpine	500	14.586	<0.0001
	150	3.505	0.0002
	50	3.505	0.0002

Highest activity levels were associated with stands of large Sitka Spruce and Western Hemlock. The number of detections per survey at low and high elevation plots were higher at plots in Vegetation Group 7, where trees were largest (mean dbh = 141.2 ± 7.9 cm), than in all other plots combined (mean dbh = 60.2 ± 3.6 cm; Kruskal-Wallis results comparing number of detections: T = 6.75; p = 0.0094), especially when only detections within 50 m of survey stations were included (T = 10.94; p = 0.0009). However, if only low elevation plots were considered, there was no difference in total number of detections (T = 0.214; p = 0.644) or in detections within 50 m (T = 1.023; p = 0.312) between plots in Group 7 and all other plots. There was also no difference in detection rates within Group 7 between site associations CwSs-F and CwSs-C (T = 0.982; p = 0.322).

4.2.2. Second-growth forest habitat:

There were very few detections of Marbled Murrelets in second-growth forest habitat. One, distant detection was recorded from the five fixed stations at Skidegate Lake and Jungle Creek (Appendix 14). Along road transects, detections were recorded primarily at stations within or adjacent to old-growth stands (Fig. 19-22; Appendix 15). Detections occurred on 76% (19 of 25) of station surveys conducted within old-growth forest habitat, and on 27% (27 of 101) of station surveys done within second-growth forest (Figs. 20-22). These proportions were significantly different (Chi-square value = 8.15; p = 0.0043), especially when only plots

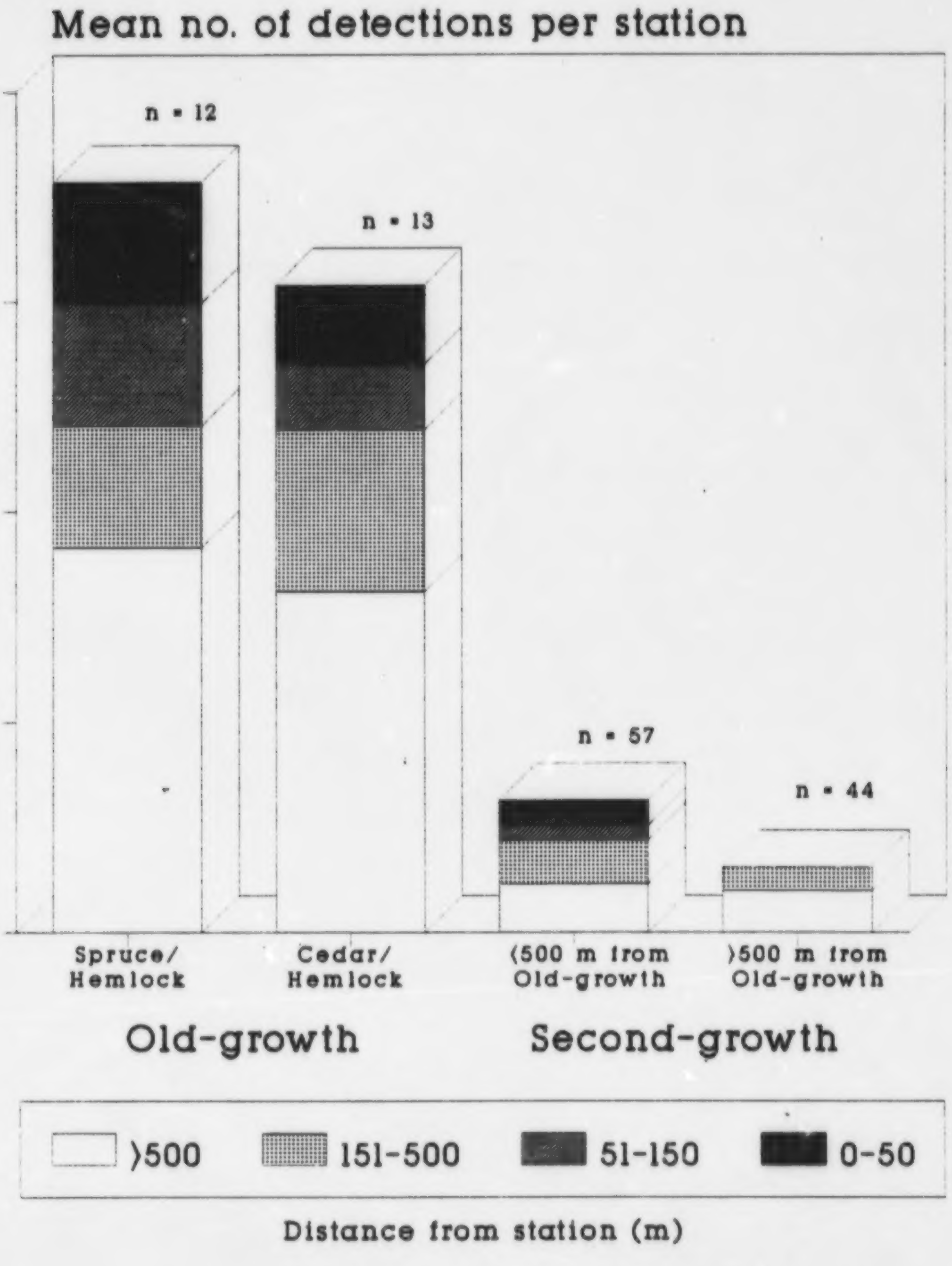


Figure 19. Mean number of Marbled Murrelet detections per road side station in relation to adjacent habitat type.

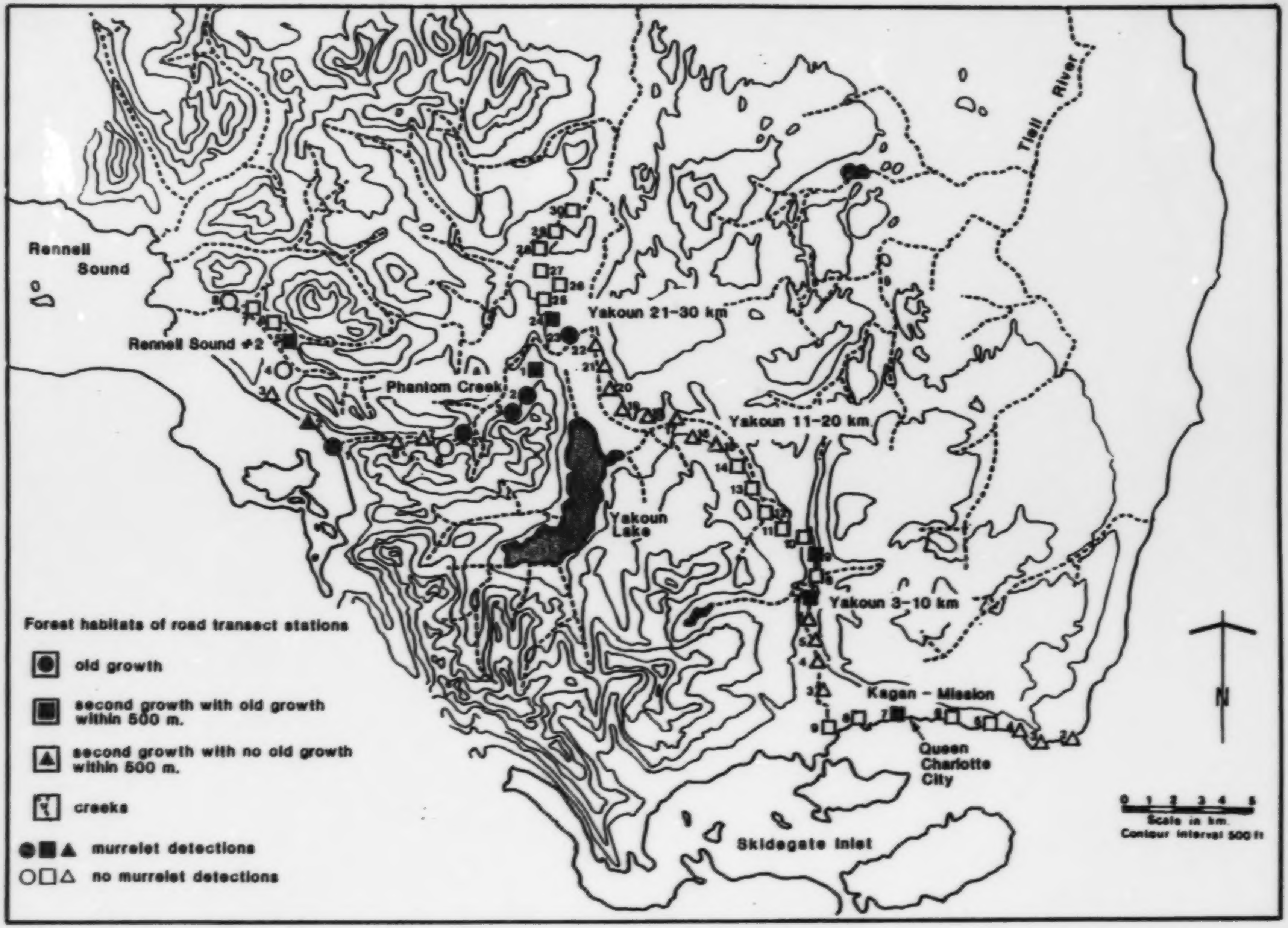


Figure 20. Number and distribution of road side stations with detections of Marbled Murrelets in May.

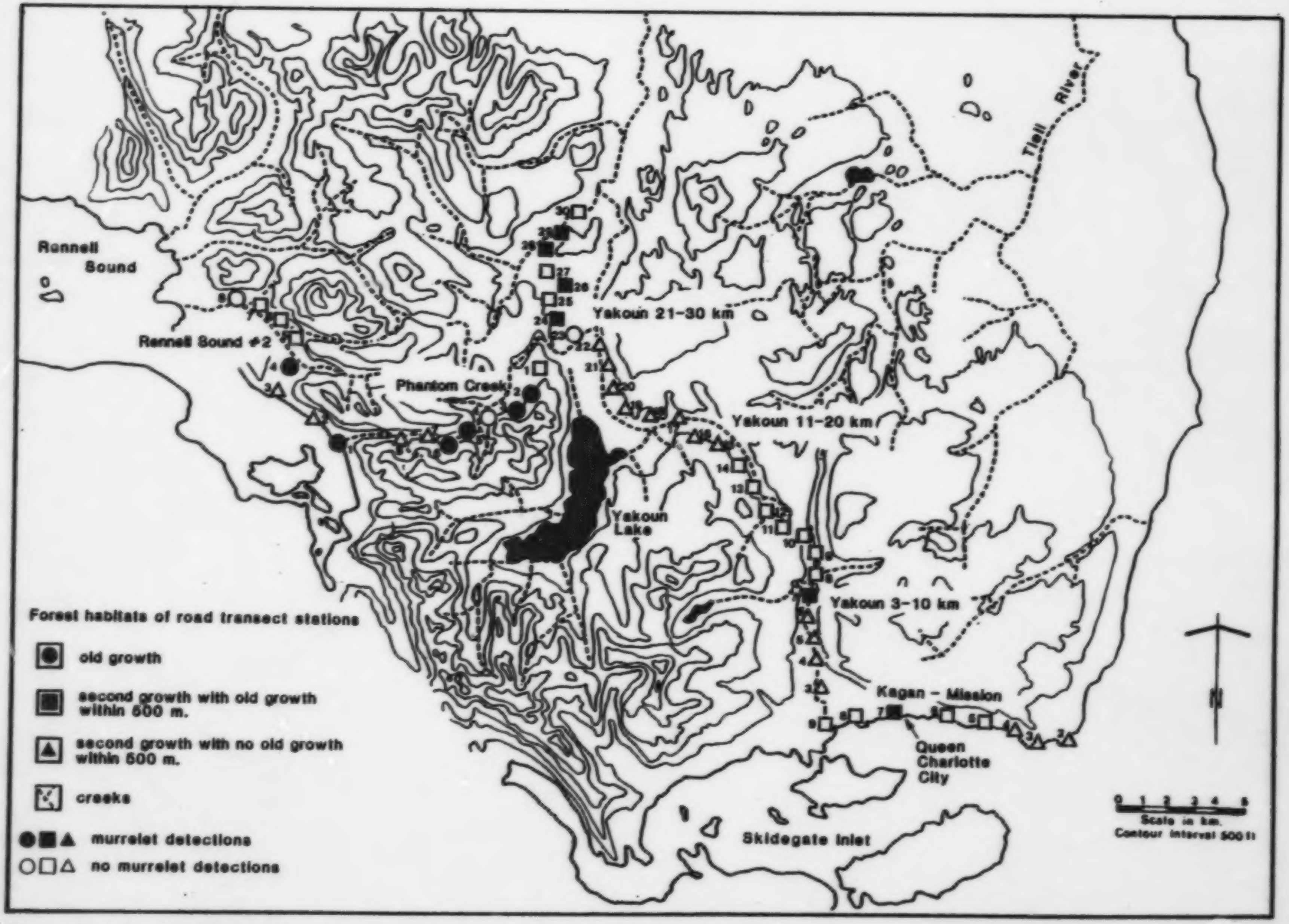


Figure 21. Number and distribution of road side stations with detections of Marbled Murrelets in June.

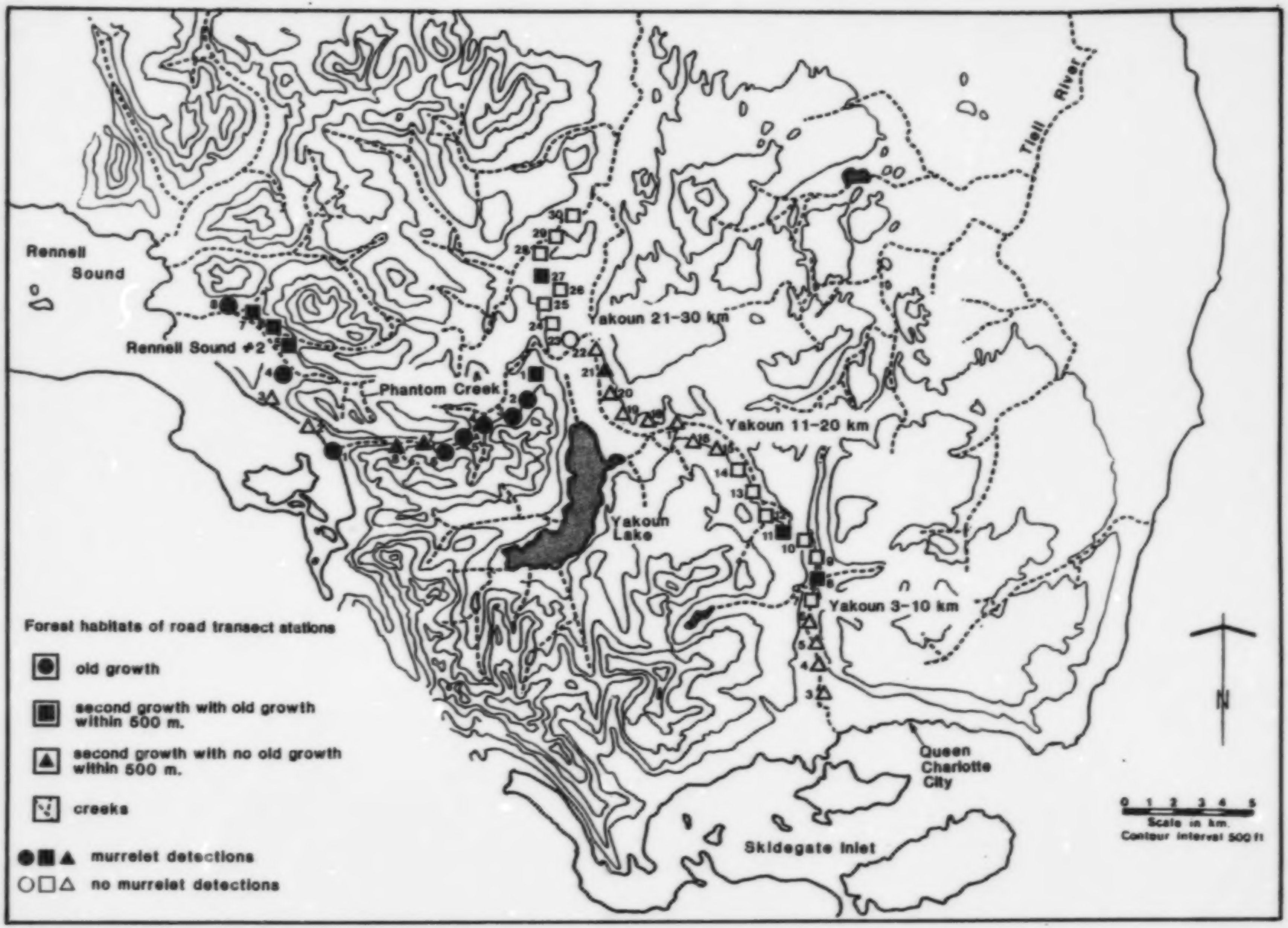


Figure 22. Number and distribution of road side stations with detections of Marbled Murrelets in July.

in second-growth habitat with no adjacent old-growth habitat were considered (Chi-square value = 36.82; p < 0.0001). In 85% (23) of the cases where detections were recorded in second-growth forest habitat, there were stands of old-growth forest within 500 m. Significantly more stations in second-growth forest that had adjacent stands of old-growth forest (within 500 m) had detections than those with no old-growth nearby (Chi-square value = 7.51; p = 0.0061; Fig. 19).

4.2.3. Other areas:

Data from other areas suggested similar patterns of habitat use as that found in Lagins Creek. Marbled Murrelets were detected in most areas surveyed except in areas of extensive second growth such as Jungle Creek (Ju.C.) and Skidegate Lake (Sk.L.) (Figs. 25-26, Appendix 14). Most sites adjacent to or within old growth forests had significant numbers of Marbled Murrelet detections. Stations at various elevations at Phantom Creek (in early May) and Mercer Lake (in July) (Figs. 23-24; Appendix 14); tended to have highest numbers of detections at plots in valley bottoms within stands of large spruce and hemlock in site associations CwSs-F, CwSs-F, and HwSs-L (Phantom Creek #3,5,7,8,12-see Appendix 3,12a; Mercer Lake #1-4). Valley bottom plots in CwSs-Sk site association (Phantom Creek #1,2&4) had fewer detections, and plots on side slopes at higher elevations (Phantom Creek #9&10; Mercer Lake #5&6) or in alpine habitat (Mercer Lake #7&8) had fewer and more distant detections, primarily of birds flying below over low-elevation

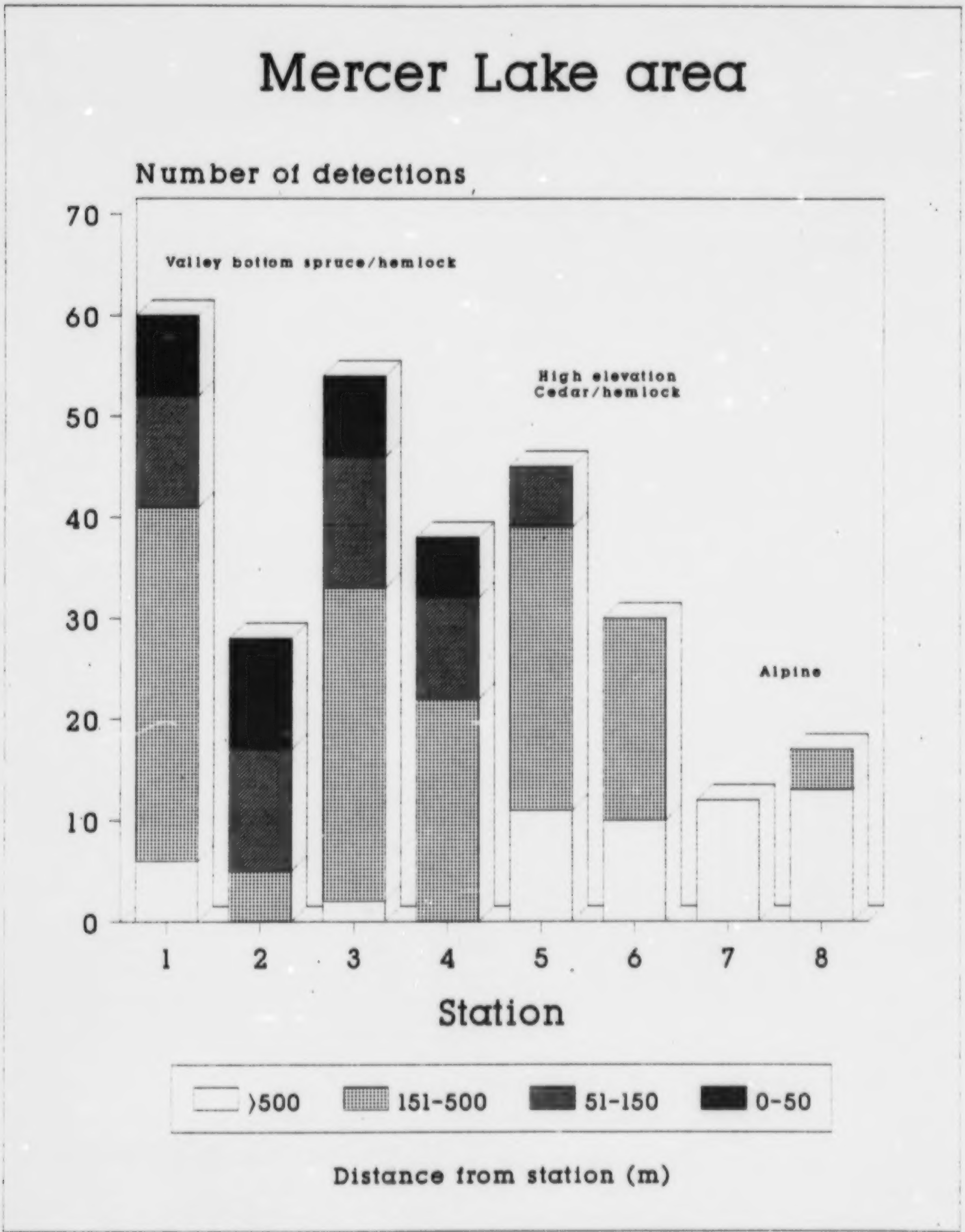


Figure 23. Comparison of the number and location of Marbled Murrelet detections in various stations at Mercer Lake in July (1 count per station).

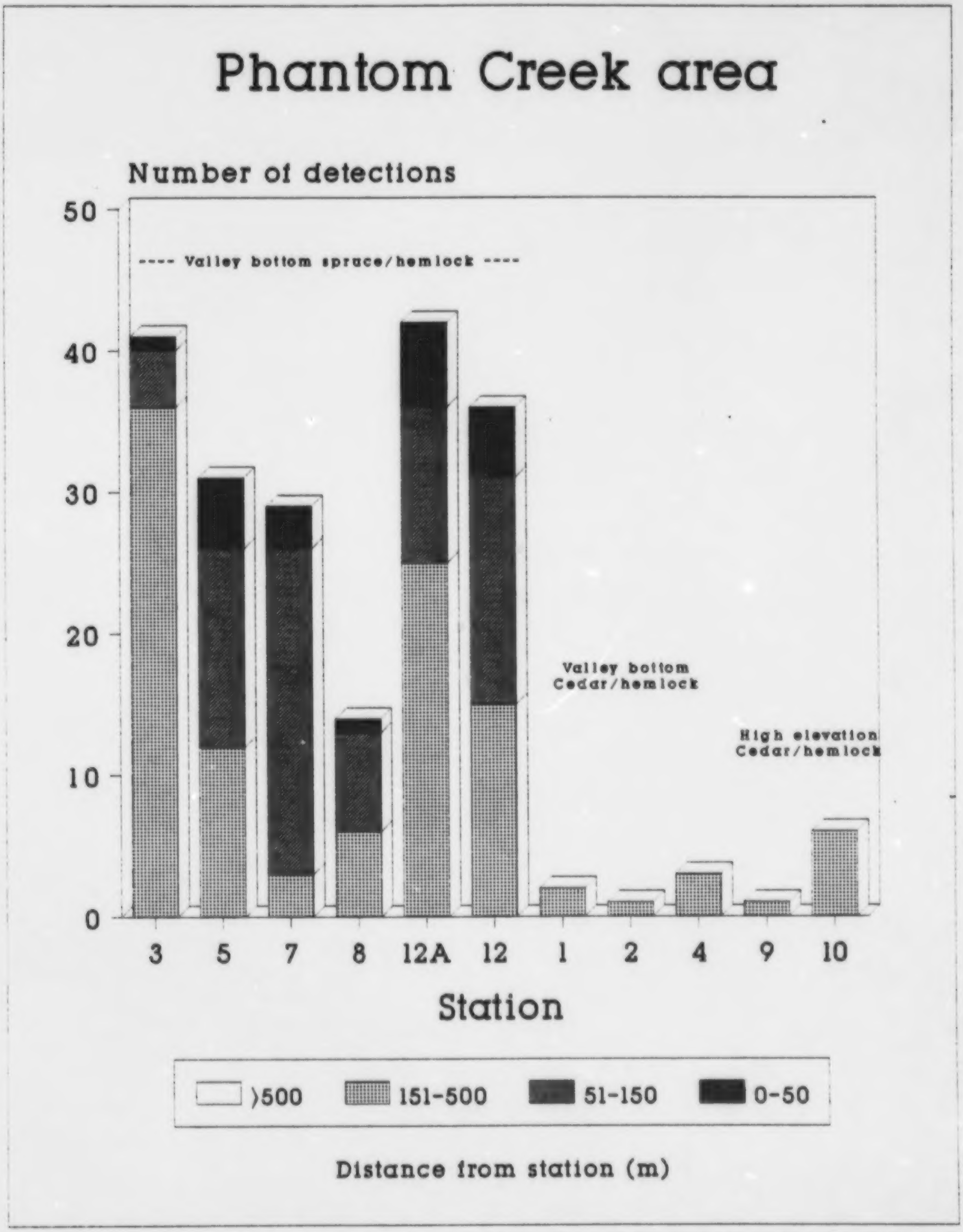


Figure 24. Comparison of the number and location of Marbled Murrelet detections in various stations at Phantom Creek in early May (maximum of 2 or 3 counts).

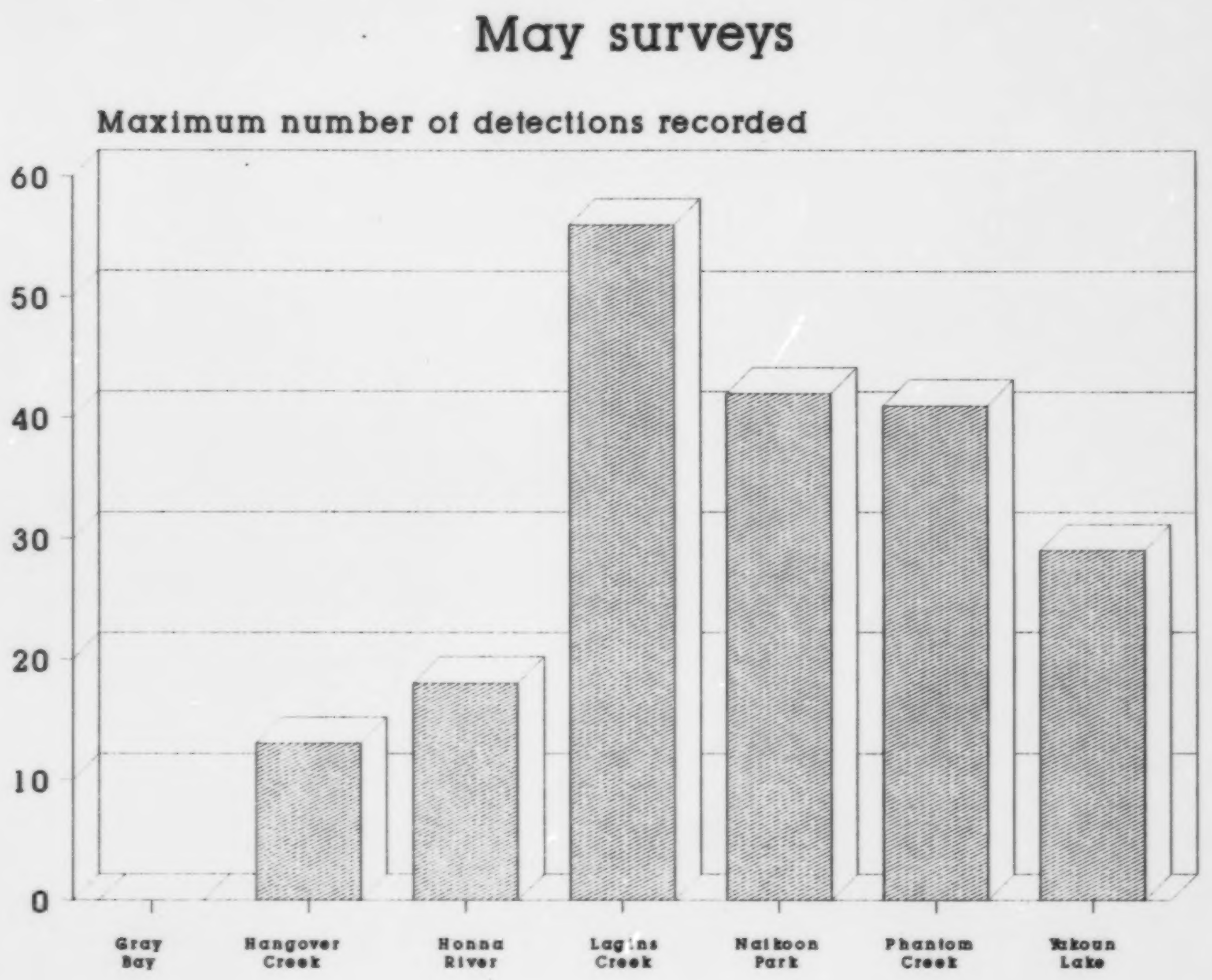


Figure 25. Number of Marbled Murrelet detections recorded at various stations located near old-growth forest in May 1990.

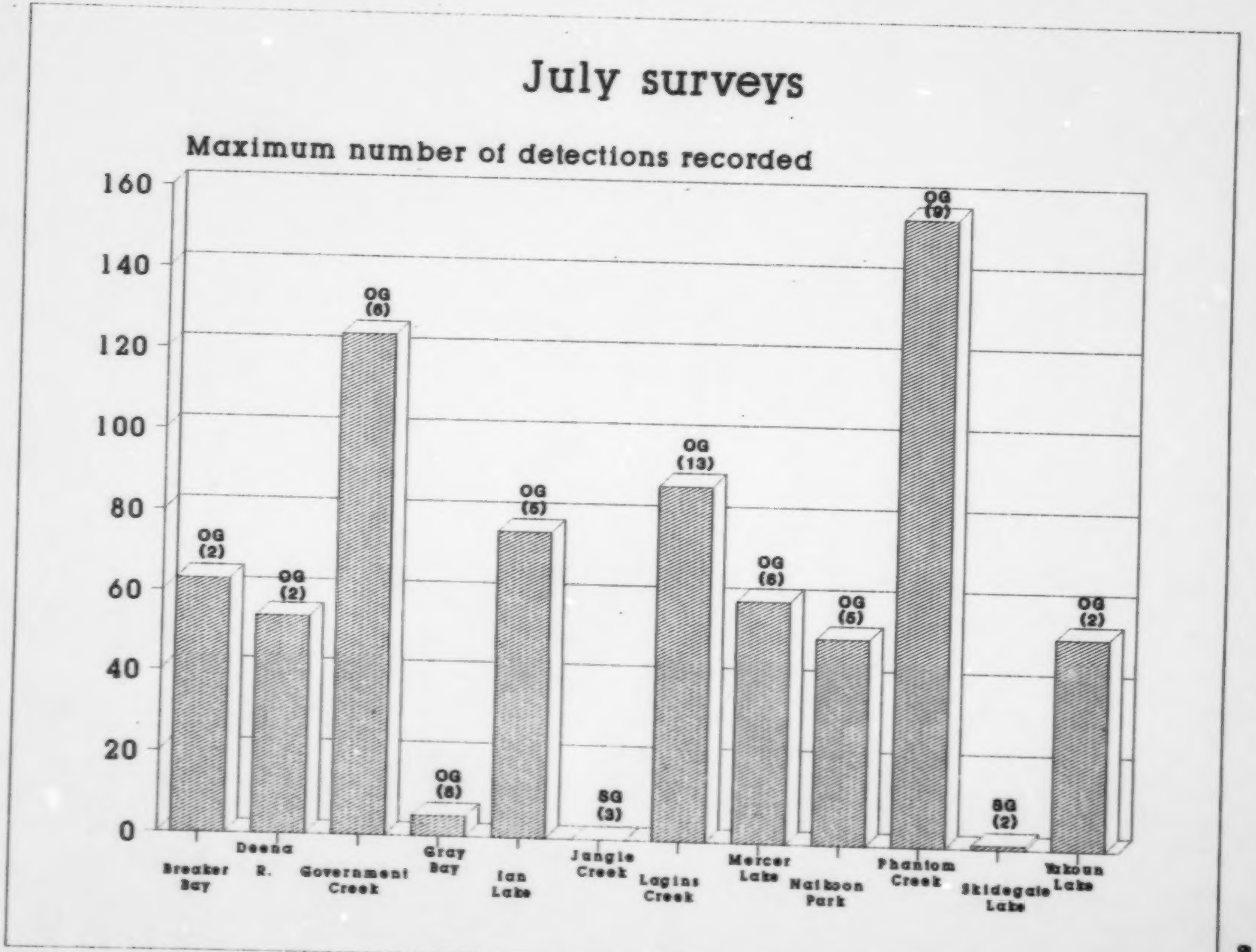


Figure 26. Number of Marbled Murrelet detections (maximum) recorded at various stations located near old-growth and second-growth forest in July 1990 (OG=old growth; SG=40-60 years old; (number of surveys).

forest. An exception to this general pattern was found at Gray Bay, where there were no detections within a stand of large spruce (at plots #1&2). The spruce trees in that area had virtually no moss development on their limbs, probably because it is a shoreline site association influenced by ocean spray.

During observations over the last 12 years at numerous lakes in the Queen Charlotte Islands, Reimchen recorded highest levels of murrelet activity at lakes in or adjacent to old-growth forest with large, moss-laden trees (Appendix 16).

5. Geographical distribution of Marbled Murrelets:

5.1. At-sea surveys:

5.1.1. Gray Bay to Cumshewa Head:

Telescope counts were made from 5 locations along the shoreline between Gray Bay and McCoy Cove (Fig. 1). Few Marbled Murrelets were sighted except just north of Cumshewa Head where a total of 77 were counted, and in Cumshewa Inlet off the east end of Kingui Island where 43 were counted (Appendix 17).

5.1.2. Masset Sound:

Few murrelets were seen along boat transects run from Port Clements to Watun Creek in Masset Sound on 4 June (Fig. 1). Over 100 Marbled Murrelets had been reported off the northwest side of Kumdis Island on 11 May (Margo Hearne pers. comm.), but only 5 were present in that area on 4 June (Appendix 17).

5.1.3. North coast of Graham Island:

Boat transects were run from Coneehaw Rock to Wiah Point on 12 July, and through McIntyre Bay north of Masset and from Striae Islands to Wiah Point on 13 July (Fig. 1). Concentrations of 168 off the mouth of Naden Harbour between Cape Naden and Cape Edenshaw, and of 116 between Striae Islands and Wiah Point were recorded. No murrelets were seen in McIntyre Bay (Appendix 17).

Aggregations had previously been sighted along the north coast of Graham Island, especially in July. On 15 July 1989, 612 were counted between Masset Sound and Pillar Bay, and 519 were recorded in Pillar Bay on 20 July 1989 (Margo Hearne pers. comm.; Fig. 1; Appendix 17).

5.1.4. Shields Bay and Rennell Sound:

Boat transects were run through Shields Bay and the eastern portion of Rennell Sound as far west as Cone Head on 4, 29, 30 and 31 May and 1 June. Telescope counts were also made from shore near Bonanza Head on 24, 25, 27 and 28 July (Fig. 1). Small clusters of 10-20 Marbled Murrelets were observed off Dawson Head and east of Clonard Bay on 4 and 29 May. Larger concentrations were seen around Gospel Island to Gospel Point (174 on 1 June) and north of Gospel Point in Bonanza Bay (121 on 27 July; Appendix 17).

5.1.5. Skidegate Inlet area:

A thorough boat survey of the Skidegate Inlet area west of Haida Point was conducted on 28 April. Various portions of the inlet were surveyed through the summer (Appendix 17). Marbled Murrelets were uncommon in most sections of the inlet. Concentrations were encountered in Long Inlet (147), off Government Creek (36) and west of Mercer Point (44).

5.2. Inland surveys:

5.2.1. Breaker Bay:

Two fixed stations were surveyed in the watershed north of Breaker Bay, just south of Vertical Point (Fig. 1). Station #1 was near the mouth of the creek in 60-80 year old second-growth forest and station #2 was near the head of the creek at the base of a slide on the edge of old-growth spruce/hemlock forest. Numbers of detections were similar at the two stations (Appendix 14). Most detections at station #1 were of distant birds flying up and down the valley. There were no detections within 50 m. Seven of 59 detections were within 50 m at station #2. Many high circling birds were seen at station #2, and activity seemed to be associated with areas on the north and south sides of the valley bottom and with areas at higher elevation to the west.

5.2.2. Deena River:

Two fixed stations were surveyed near the head of the river and one road transect with 7 stations was surveyed along the south side of the river (Fig. 1). All stations were on logging roads in proximity to stands of old-growth forest. Detections appeared to be associated with pockets of old-growth forest on sidehills, and with the leave-strip of old-growth forest along the river (Appendix 14).

5.2.3. Government Creek:

Six fixed stations were distributed from the mouth to the head of the creek. Stations 1,2,4 and 5 were in old-growth spruce/hemlock forest in the valley bottom, station 3 was at the head of the creek in pine/cedar bog, and station 6 was in cedar/hemlock forest on a sidehill approximately 150 m elevation above the valley bottom. High levels of activity were recorded at all stations. Detections were highest and many close birds flying below the canopy were seen in the valley bottom. Station 3 was at a confluence of three valleys and appeared to be on a major flight corridor with birds flying in all directions. Most detections at station 5 were of distant birds flying below over the valley, though a few birds were seen flying high above the station.

5.2.4. Gray Bay:

Ten fixed stations were surveyed in old-growth forest between Gray Bay and McCoy Cove (Fig. 1). Very few detections were recorded at any station (Appendix 14). There was little moss development on tree limbs in this area. The only area with any moss development on tree branches was in the drainage behind Kids Cove which was not surveyed. The forest in this area of the coast gives way rapidly to dense cedar-salal combination. The coastal strip of Sitka Spruce is very narrow, less than 10 m wide, with only occasional low angle valleys where spruce forests extend further inland.

5.2.5. Hangover Creek:

There were 13 detections at the one fixed station surveyed at the edge of old-growth spruce/hemlock forest along the west side of the creek (Fig. 1; Appendix 14).

5.2.6. Honna River:

There were 18 detections recorded at the one fixed station surveyed at the edge of old-growth spruce/hemlock forest on the north side of the river (Fig. 1; Appendix 14).

5.2.7. Ian Lake:

Stations 1 and 2 at the northeast end and station 5 at the southwest end of the lake were in stands of large spruce and hemlock, and stations 3 and 4 were along the northern shore of the lake on the edge of cedar/hemlock forest (Fig. 1). High activity was recorded at all stations, though only at stations 1,2 and 5 were birds flying into the forest (Appendix 14). Many birds circling high across the entire width of the lake were seen at stations 3 and 4. The activity at those stations did not seem to be associated with the adjacent forest; birds appeared to be flying to and from other areas.

5.2.8. Jungle Creek:

There were no detections at the three stations surveyed in second-growth forest near Jungle Creek (Fig. 1; Appendix 14).

5.2.9. Mercer Lake:

Eight fixed stations were distributed in valley bottom spruce/hemlock forest (1-4), on high elevation sidehills (5-6) and in alpine habitat (7-8; Fig. 1). Total numbers of detections and detections in close proximity to survey stations were highest in the valley bottom (Fig. 16). Detections at high elevation and alpine stations were primarily of birds flying below in the valley (Appendix 14).

5.2.10: Naikoon Park (Tow Hill and Hiellen River):

We surveyed 7 stations in spruce/hemlock forest along the Hiellen River (#1-2, 4-7) and on the east side of Tow Hill (#3; Fig. 1). Station 2 was over 1 km inland along the east side of the river in a very wet area with fewer large spruce than at stations 1, and 4-7 which were closer to the mouth of the river. Many murrelets were seen flying below tree-top along the river and through the forest, especially at stations 1 and 6. There were fewer detections farther inland and on the east side of Tow Hill at stations 2 and 3 (Appendix 14).

5.2.11. Phantom Creek:

We surveyed 12 fixed stations along Phantom Creek prior to establishing the permanent study station there (Fig. 1). Stations 3,5,6,7,8 and 12a were in or adjacent to spruce/hemlock forest in the valley, stations 1,2, and 4 were adjacent to cedar/hemlock forest in the valley, stations 9 and 10 were on sidehills in cedar/hemlock forest 150 m above the valley, and station 3 was in a clearcut block about 200 m from old-growth forest. Highest numbers of detections were recorded at stations in or near to spruce/hemlock forest, few were recorded in cedar/hemlock forest in the valley or on the sidehills. There was one detection at station 11 in clearcut (Appendix 14).

5.2.12: Skidegate Lake:

Only one, distant detection was recorded at the two fixed stations surveyed in second-growth forest along the north side of Skidegate Lake.

5.2.13. Yakoun Lake:

Twelve fixed stations were distributed around Yakoun Lake (Fig. 1). Stations 1-2, 6-8 and 10-12 were in or on the edge of spruce/hemlock forest, station 9 was on the water about 200 m offshore from a stand of spruce/hemlock forest, stations 4 and 5 were in cedar/hemlock forest, and station 3 was on a sidehill in cedar/hemlock forest 150 m above the lake. Detections tended to be highest in spruce/hemlock forest, although there were few detections at stations 2, 6, 7 and 8 in May. Stations 1, 2, 6 and 7 were surveyed in early May and then again in late June. Numbers of detections were higher in June at all stations except 7. All detections at station 3 were of distant birds, and all but one were flying below near the lake (Appendix 14).

5.2.14. Other lakes:

T. Reimchen has conducted cursory surveys of Marbled Murrelet activity at many lakes in the Queen Charlotte Islands. Highest activity levels were recorded at lakes on the west side of Graham Island, especially in the vicinity of Coates Lake and Seal Inlet (Appendix 16).

DISCUSSION

1. Inland activity patterns:

1.1. Daily and seasonal activity patterns:

The wide variation in activity levels on a daily and weekly basis recorded in this study has been noted before (Nelson 1989). The causes of this variation are still unknown but may include weather factors, vocalization behaviour and flight patterns of murrelets. Because of this large variability in detection levels from day to day, caution must be taken when comparing different areas, especially when surveyed on different days or under different conditions.

The seasonal pattern of increased activity in July has been observed in several other studies: Nelson (1989) in Oregon, noted highest numbers of detections between 12 July and 9 August with a peak in late July. She also noted that activity levels dropped off abruptly in early August and that most sites were devoid of murrelets in mid to late August. Ralph et al. (1989) observed similar activity patterns in California.

There seems to be some variation in activity patterns between areas. Nelson (1989) reported a minor peak in detections in late May to early June, whereas Burger et al. (1990) reported a peak in late June. In our study we observed differences between our two permanent stations. Both stations had a slight rise in number of detections in late May, but number of detections decreased in early June at Lagins Creek while increasing at Phantom Creek. A possible difference between the two sites is the likelyhood that Phantom Creek is on a flight path for murrelets while Lagins Creek, being located at the end of an inlet, is less likely to serve as a flight corridor. If this is the case then patterns observed at Lagins Creek may reflect more closely what could be observed at breeding areas.

1.2. Effect of weather on murrelet activity:

Murrelets tended to be detected more frequently on cloudy days and to be active for longer periods than on clear days. Nelson (1989) noted that the number of detections varied with weather conditions, but found that most detections occurred on clear and completely overcast days and that fewer detections were recorded on moderately cloudy days. Paton et al. (1988) and Ralph et al.

(1989) found that murrelet activity tended to start later on foggy and misty mornings but continued for a longer period of time and appeared to be more intense than on clear days.

The trend in our study and that of Paton _et al_. (1988) and that of Ralph _et al_. (1989) indicate a relationship between light conditions and the intensity and duration of murrelet activity. Weather is a major factor contributing to daily variability in the number of murrelet detections at a given site, and should be taken into consideration when comparing murrelet activity between sites.

1.3. Correlation of murrelet activity between sites:

Although there was a significant correlation in murrelet activity patterns between our two permanent stations, there were important differences. Both areas had similar seasonal patterns but there was considerable variablity on a daily and weekly basis, detections often increasing in one area while decreasing in the other. Local weather patterns sometimes differed and may have contributed to differences in activity levels, but we cannot pinpoint at this time the factors besides weather that may have accounted for the different patterns observed in the two areas.

2. Behaviour:

Murrelets were sighted in 19% of detections at Lagins Creek and 26% of detections at Phantom Creek. The difference between the two areas possibly reflects different observation conditions, with more sky being visible at the Phantom Creek station. Nelson (1989) reported 32% visual detections in Oregon, and Paton and Ralph (1988) reported 25% visual detections in California. Several studies (Nelson 1989, Paton and Ralph 1988, Varoujean et al. (1989) have indicated that visual detections are crucial in identifying potential nesting areas. Birds flying below the canopy, birds landing in trees, and silent birds flying through the forest all could indicate potential nesting and/or roosting sites. The relatively low proportion of visual detections emphasizes the large effort required to survey large geographical areas and identify potential nesting areas.

Most murrelets sighted were either flying alone or in pairs. Larger groups were more often seen in July, possibly indicating the presence of non-breeders at this time. Sightings in May and June may represent mostly breeding birds and may provide a better indication of potential nesting sites. Single birds flying are likely associated with breeding. This is supported by the high frequency of single birds that are silent. Murrelets should be silent in proximity to their nests to minimize the danger of nest detection by predators. The higher incidence of calls in larger flocks suggests that one of the main purposes of calls is the maintenance of pair and group unity during flight, especially in darkness. Birds flying above the canopy were more likely to call than birds flying below. The former were more likely to be in transit and possibly used calls to maintain auditory contact. Birds flying below the canopy are likely more vulnerable to nocturnal predators and would benefit by being less conspicuous.

The larger number of detections recorded on cloudy and foggy mornings may be due in part to an increase in vocalisation due to lower light conditions. The high frequency of silent single or paired birds stressed the importance of selecting observation stations in areas maximizing the chances of visual detections, i.e. with large sections of open sky.

3. At-sea activity patterns:

3.1. Seasonal abundance:

The numbers of Marbled Murrelets in Long Inlet varied greatly on a daily and seasonal basis suggesting a complex use of the marine environment. The high daily variability in the number of murrelets frequenting the inlet indicates that the birds often go outside the inlet to feed. Varoujean et al. (1989) who followed Marbled Murrelets with radio telemetry in Oregon during the breeding season recorded extensive movements of murrelets at sea. One of their marked birds, which was using a grove of trees 22 km inland from the mouth of the Umpqua River, ranged over the next nine days within 4 km of the mouth of the river. Given that birds have been observed up to 100 km inland (Rodway 1990) they likely can cover large areas at sea to take advantage of feeding opportunities. Wide dispersal at sea for feeding may account for the low proportion of birds holding fish in their bills observed during this study.

Maximum counts in Long Inlet were recorded in mid-May, but daily and weekly averages were highest in July. Carter (1984) observed a significant increase in the number of Marbled Murrelets at sea in Barkley Sound toward the end of June and beginning of July. Kaiser et al. (1991) found that the murrelet population he was observing near Powell River, B.C. nearly doubled in July. The increase in the number of Marbled Murrelets in coastal areas in July is thought to be due to the arrival of non-breeders near breeding areas. This has not been confirmed yet but the pattern parallels similar happenings in other seabirds where the number of non-breeders increase in the colonies toward the end of the breeding season (Manuwal 1974a, Sealy 1976, Wilson 1977, Gaston 1990).

3.2. Group size and breeding chronology:

We hoped at the beginning of the study that we would be able to determine the breeding chronology of murrelets by noting the fluctuations in the ratio of single and paired birds. This proved difficult because of the high variability in murrelet counts and the relatively low abundance of murrelets in our study sites. Highest numbers of single birds were recorded in mid-May in Long Inlet and in mid-June in Shields Bay, and the ratio of single to paired birds peaked in mid-June in both areas. In Long Inlet, the number of single birds remained relatively constant from late May to July contrasting with an increase in the number of pairs. The predominance of single birds in May and June may correspond with the incubation period and early chick rearing period when a parent remains with the chick. The increase in the number of pairs in

July may reflect the fact that both parents are now feeding the chick, and doing so at similar times. It probably also shows an increase in nest prospecting by non-breeding or unsuccessful pairs. Similarly, the proportions of single birds and birds flying below the canopy, most of which were silent, were highest in June at the inland station in Phantom Creek, suggesting that birds were incubating at that time. If the ratio of single to paired birds reflected the frequency of incubating birds it would suggest that most birds were incubating in mid-June, and that most chicks had hatched by mid-July. This would agree with the phenology derived by Sealy (1974) at Langara Island off the northwest corner of Graham Island. The first bird seen holding fish in Shields Bay on 12 June also corresponds closely to the earliest date of 13 June recorded by Sealy. However, the high proportion of single birds in Long Inlet in mid-May, and the appearance of juveniles on the water beginning on 12 June suggests an earlier phenology than that observed by Sealy, who saw the first young at sea on 6 July. In the southern Strait of Georgia, young of the year are more commonly sighted in early to mid-June. On the north coast and Queen Charlotte Islands, young have rarely been seen before July, although the earliest record of young at sea in B.C. on 28 May was from the east coast of the Charlottes (Rodway 1990).

3.3. Abundance at-sea in relation to activity levels at adjacent inland stations:

The seasonal abundance of murrelets in Long Inlet and the seasonal level of activity recorded at the Lagins Creek permanent station were positively correlated. The increase in the number of murrelets in Long Inlet in July coincided with an increase in murrelet activity in the forest. This peak in activity in July has been a common feature of all murrelet studies to date (Nelson 1989, Paton et al. 1988, Burger et al. 1990, Carter and Erikson 1988).

We did not observe the same pattern in Shields Bay, mostly because of overall low murrelet numbers. Because we could only cover the inlet from the ground, we missed large areas of the inlet. Murrelets appeared to concentrate near the mouth of Rennell Sound, an area not covered by our ground surveys.

4. Functions of Marbled Murrelet flight activities:

At this stage of Marbled Murrelet research, the significance and functions of murrelet flights in and over the forest is still a mystery. We list here some possible functions.

4.1. Nest searching

The nine nests found to date south of Alaska suggest that murrelets may seek specific characteristics in a nest site. Such characteristics possibly include some kinds of visual protection of the nest from above, easy access by the birds, and sufficient platform surface (Binford et al. 1975, Singer et al. in prep., Quinlan and Hughes 1990). Thus the finding of a suitable nest site likely may require a lengthy search. Because both parents incubate and feed the young (Simons 1980), both have to know the exact location of the nest. Therefore, either both parents prospect together for a suitable nest site or one of the parents has to show the nest location to the other. It is likely that some of the circling behaviour observed permits birds to familiarize themselves with the location of the nest and/or nesting groves. It is still unknown when Marbled Murrelets select their nesting site.

Several seabirds do prospect for nest sites in the year(s) preceding first breeding (Manuwal 1974a, Sealy 1976, Gaston 1990). This behaviour has been well documented in cavity nesting waterfowl where non-breeding females prospect for nest sites late in the breeding season (Patterson 1982, Eadie and Gauthier 1985). It would not be surprising if some of the murrelet forest activity in July involved non-breeding birds inspecting potential nest sites and/or familiarizing themselves with various breeding areas.

Some nest prospecting by breeding birds must occur early in the spring; what proportion is not known. Renesting has not been confirmed yet in the Marbled Murrelet, however the large spread of the breeding season and the seemingly high predation pressure on the species suggest that it may occur. If so, then renesting birds must prospect for new nesting sites during the breeding season. Birds unsuccessful in their breeding attempts usually change nesting sites (Savard 1988, Dow and Fredga 1985). The two nests found in California in 1989 and which had been depredated, were not reused by murrelets in 1990 (Nelson pers. comm.).

4.2. Mating behaviour

Nothing is known about the pairing behaviour of Marbled Murrelets. It is not known when or where it occurs. Cassin's Auklets (*Ptychoramphus aleutica*) and Ancient Murrelets (*Synthliboramphus antiquus*) have elaborate displays in their breeding colonies at night, and pairing may occur there (Manuwal 1974b, Thorensen 1964, Sealy 1976, Jones 1985, Gaston 1990). Some of the aerial displays observed over the forest may be associated with either pairing behaviour, or pair bond maintenance and/or enhancing behaviour. Like most seabirds, Marbled Murrelets are expected to mate for several years.

4.3. Spacing behaviour

Concealment appears to be the key to Marbled Murrelet nesting success. Three of the nests found in the past two years were depredated. A Common Raven (*Corvus corax*) ate one egg, a Steller's Jay (*Cyanocitta stelleri*) killed one chick (Singer *et al*. in prep.), and a Great Horned Owl may have killed a chick (Nelson pers. comm.). Whether Marbled Murrelets are semi-colonial or not is still a matter of speculation but it is likely that given their nesting preferences and reliance on concealment, that widely spaced nests would be preferred. If this is the case we could expect that some types of spacing behaviour may have evolved in breeding pairs. Cassin's Auklets are territorial during the breeding season and this behaviour prevents some birds from breeding (Manuwal 1974a). Whether Marbled Murrelets are territorial or not is presently unknown. Some of the aerial flights observed may include some spacing behaviour.

4.4. Flight corridors

Marbled Murrelet activity has been noted up to 70 km inland. Several nests have been found over 20 km inland. Thus birds have to travel from the ocean to these sites and may use preferred flight paths. Thus, some of the flight activity observed undoubtedly included birds flying to or returning from inland sites. Because most detections are auditory and because high flying birds are more likely to be vocal, birds in transit may comprise a substantial proportion of murrelet detections.

4.5. Others

Circling behaviour of colonial alcids is well known where birds often circle several times before landing in the colony. Explanations range from predator avoidance (Grant 1971), social functions (Lockley 1953), courtship activities (Allan 1962) and better location of nest site.

It is likely that Marbled Murrelet flight behaviour includes various proportions of the above phenomena. Hopefully, continued observations with the help of night viewing equipment, will enable us in the next few years to establish the significance and functions of Marbled Murrelet flights in forested areas.

5. Marbled Murrelet activity in relation to habitat type:

In this study, Marbled Murrelet detections were most numerous in valley bottoms in the vicinity of old-growth spruce and hemlock forest with mean tree sizes in excess of 1.0 m dbh. This relationship between tree size and number of detections has been observed in other studies (Nelson 1989, Paton and Ralph 1988, Paton et al. 1988). There were fewer murrelet detections in alpine areas than in forested areas and more detections in May and July but not in June in old-growth forest at lower elevations than higher ones. Few murrelet detections were recorded in second-growth forest (40-60 years old) compared to old-growth forest. This is not surprising as second growth forest of the Queen Charlottes are relatively young and do not contain many vestiges of old-growth forest. Nest site availability in these forests is low as there is not many large branches that could support a murrelet nest.

Nests have been found in mature forests in Oregon (Nelson pers. comm.). However these mature forests contained old-growth remnants and the nests were found in those large trees. Murrelets have been detected in small old-growth stands (50-100 ha) in California and Oregon (Nelson 1989, Paton et al. 1988) but small, fragmented blocks have not been investigated in British Columbia.

6. Survey methods and considerations:

There are problems and limitations to using number of detections as an indicator of habitat use. Marbled Murrelets can be heard and seen at different distances in different habitats, depending on the exposure of survey stations. Thus, higher numbers of detections may be recorded at some locations because murrelets can be heard and seen over a greater range than at other locations. Murrelets can circle over the forest covering large areas. One could argue that if a murrelet circles over the bottom of a valley covering both sides we would expect more detections in the valley bottom. Two birds circling either side of a valley may both traverse lower, central forest, while only one will pass over higher elevation forest on each side. If birds flying to a given area are more likely to follow the bottom of the valley than the sides, then birds originating from the water would traverse low elevation forest in route for higher elevation forest, while birds staying in low elevation forest would not be detected in higher elevation forest.

Visual and auditory acuity of different observers may affect numbers of detections recorded. While training one new observer, we found that she could see birds at much greater height than the experienced person training her. On her first two days she saw over twice as many birds as her trainer, though overall numbers of detections recorded were similar. To minimize observer differences, we changed observers as little as possible, trained replacement personnel by the person being replaced, and analysed numbers of detections occurring within specific radii of survey stations.

There is a limitation of scale in using detections as an index of habitat use. Activity of murrelets recorded as a detection rarely occurs at a single point in space, and usually encompasses an area several hundred meters wide. Thus, the association of detections with habitat can only be defined on a coarse scale. Changes in forest habitat often occur over a smaller scale than can be resolved by analysing murrelet activity. In the Lagins Creek study area, we found a relationship between low-elevation forest and high numbers of detections, but within low elevation areas, we could not discriminate activity levels in stands of large spruce and hemlock near plots 16 and 21 from that in adjacent pine bog around plots 23 and 24, located approximately 200 m from the edge of the spruce/hemlock forest. We suspected that all activity over the pine bog was associated with the spruce/hemlock forest, but the number of detections in both habitats were similar.

No nests were found in this study, and we cannot translate frequency of detections into density, or even occurrence of nest sites. Intensive studies are needed to locate nests, describe specific nesting habitat requirements, determine spatial distribution of nest sites, and monitor activity levels in relation to nesting density, before we can relate numbers of detections to habitat use.

7. Recommendations

1. Fixed stations to monitor Marbled Murrelets should be located in areas maximizing the chances of visual detections (i.e. areas with greatest % of open sky or at the edges of clearings). Visual detections are crucial to identifying

potential breeding areas. Murrelets associated with nest sites tend to be silent when flying (Singer et al. in prep.).

2. Because of the small proportion of visual sightings, the large area covered by circling birds, and our poor understanding of flight behaviour and function, associations of murrelet activity level with local habitat is not recommended at this time.
3. Comparisons of the level of Marbled Murrelet activity between areas should be done cautiously, taking into consideration the daily, seasonal and geographic variations in the level of activity of Marbled Murrelets.
4. Marbled Murrelet activity surveys should be conducted in partially harvested watersheds where valley bottom old-growth has been harvested. This may provide a better indication of the use of high elevation old-growth.
5. Inland surveys should be conducted on a broad scale, and special attention should be focused on the north and west sides of Graham Island as that is where the largest at-sea concentrations of Marbled Murrelets have been encountered in the Queen Charlotte Islands.
6. Results of at-sea surveys in Long Inlet suggest a possible seasonal relationship between murrelet numbers on the water and activity levels in adjacent forest. However, contrary results in Shields Bay caution that at-sea surveys may not always reflect the use of adjacent inland habitat. More research is clearly needed. The high daily and weekly

variability in murrelet numbers requires that surveys be replicated at various times and dates. More extensive at-sea surveys may provide estimates of the proportion of birds feeding young and of fledging success.

7. Use of radio telemetry will be crucial to the investigation of the at-sea ecology of Marbled Murrelets, and hopefully will help locate nest sites and clarify the relationship between at-sea and inland distribution.

8. Concluding remarks

In spite of the research efforts of the past few years both in the United States and Canada, we still know very little about the ecology and nesting requirements of Marbled Murrelets. To ensure the long-term survival of the species, information is needed not only on its breeding ecology but also on its feeding, migrating and wintering ecology.

Research in the United States has focused on identifying the inland geographical distribution of Marbled Murrelets, concentrating lately on identifying possible nesting sites. Some effort has been made on at-sea distribution and behaviour. Research in Canada has followed a similar pattern, although it is lagging behind in terms of effort.

One of the objectives of our research effort this year was to identify the strengths and weaknesses of inland murrelet surveys, and assess the potential of at-sea surveys. The results have shown the great variability of counts relying on morning detections and indicate that unless large sample sizes are taken, only coarse comparisons between areas can be made. This parallels the findings in California and Oregon (Carter and Erickson 1988, Nelson 1989).

SUMMARY

1. The number of Marbled Murrelet detections at a given inland site was highly variable with coefficients of variations around 30-40%.
2. The number of detections, number of calls and the lengths of the activity period were correlated on a coarse scale (seasonally) but not always on a fine scale (weekly).
3. The number of Marbled Murrelet detections at a given inland site peaked in July.
4. Marbled Murrelet detections were two to 40 times as numerous in the morning than in the evening.
5. More Marbled Murrelet detections were recorded on cloudy mornings than on clear mornings.
6. Marbled Murrelet activity started later and lasted longer on cloudy days than on clear days.
7. Most Marbled Murrelet detections were auditory only. Birds were seen in 19% of the detections at Lagins Creek and 26% at Phantom Creek.
8. Approximately half of the visual detections were of silent birds.

9. Most birds sighted were either singles or in pairs and the majority of single birds were silent and tended to fly at lower altitudes than grouped birds.

10. The abundance of Marbled Murrelets in Long Inlet varied daily, weekly and seasonally.

11. The abundance of Marbled Murrelets on the waters of Long Inlet decreased from May to June and increased again in July.

12. The seasonal variation in the number of Marbled Murrelet inland detections at Lagins Creek paralleled the seasonal variation in the number of Marbled Murrelets using Long Inlet.

13. The number of Marbled Murrelet detections was higher in old-growth forests than in alpine areas where murrelet detections were mostly of distant birds flying over the valley.

14. Some Marbled Murrelets flew across alpine areas en route to valleys.

15. The number of Marbled Murrelet detections was higher in low than in high elevation old-growth forests in May and July, but not in June.

16. The number of Marbled Murrelet detections was very low in second growth forests (40-60 years old) and tended to be distant detections.

17. Roadside transect stations located adjacent to old-growth had more frequent Marbled Murrelet detections than stations adjacent to second-growth.

18. Marbled Murrelets were detected in most old-growth areas sampled.

LITERATURE CITED

Allan, R.G. 1962. The Maderan Storm Petrel (Oceanodroma castro). Ibis 103: 274-295.

Banner A., Green, R.N., Inselberg, A., Klinka, K., McLennan, D.S., Meidinger, D.V., Nuzdorfer, F.C., and Pojar, J. 1990. Site classification for coastal British Columbia. B.C. Min. For. pamphlet.

Binford, L.C., Elliott, B.G. and Singer, S.W. 1975. Discovery of a nest and the downy young of the Marbled Murrelet. Wilson Bull. 87:303-319.

Burger, A.E., Manley, I. and Short, R. 1990. Marbled Murrelet (Brachyramphus marmoratus) activity patterns in Carmanah Valley, British Columbia, 1990. Unpublished Report Biology Dept. Univ. Victoria.

Carter, H.R. 1984. At-sea biology of the Marbled Murrelet (Brachyramphus marmoratus) in Barkley Sound, British Columbia. M.Sc. thesis, Univ. Manitoba, Winnipeg. 143pp.

Carter, H.R. and Sealy, S.G. 1984. Marbled Murrelet mortality due to gill-net fishing in Barkley Sound, British Columbia. In: Nettleship, D.N., Sanger, G.A. and Singer, P.F. (eds.). Marine birds: their feeding ecology and commercial fisheries relationships. Spec. Publ. Canadian Wildlife Service Ottawa.

Carter, H.R. and Erickson, R.A. 1988. Population status and conservation problems of the Marbled Murrelet in California, 1892-1987. Unpubl. rept., California Dept. Fish Game, Sacramento, California. 68pp.

Day, R.H., Oakley, K.L. and Barnard, D.R. 1983. Nest sites and eggs of Kittlitz's and Marbled Murrelets. Condor 85(3):265-273.

Dow, H. and Fredga S. 1985. Selection of nest sites by a hole-nesting duck, the goldeneye (Bucephala clangula). Ibis 127:16-30.

Eadie, J.Mc.A. and Gauthier, G. 1985. Prospecting for nest sites in cavity-nesting ducks of the genus Bucephala. Condor 87:528-534.

Eisenhawer, A.E. and Reimchen, T.E. 1990. Inland flight patterns of Marbled Murrelets (*Brachyramphus marmoratus*) on the Queen Charlotte Islands, British Columbia. Can. Field-Nat. 104:439-444.

Gaston, A.J. 1990. Population parameters of the Ancient Mur relet. Condor 92:998-1011.

Grant, P.R. 1971. Interactive behaviour of puffins (*Fratercula arctica L.*) and Skuas (*Stercorarius parasiticusl*). Behavior 40:263-281.

Hirsch, K.V., Woodby, D.A. and Astheimer, L.B. 1981. Growth of a nestling Marbled Murrelet. Condor 83:264-265.

Hoeman, J.V. 1965. Marbled Murrelet breeding record from Kodiak. Bull. Alaska Ornithol. Soc. 5:9.

Johnston, S. and Carter, H.R. 1985. Cavity-nesting Marbled Murrelets. Wilson Bulletin 97:1-3.

Jones, I.L. 1985. Structure and function of vocalizations and related behaviour of the Ancient Murrelet (*Synthliboramphus antiquus*). M.Sc. Thesis, Univ. of Toronto, Toronto, Canada.

Kaiser, G.W., T.E. Mahon, and M.D. Fawcett. 1991. Studies of Marbled Murrelets in marine habitats during 1990. Technical Report Series No. 131, Can. Wildl. Serv. Pacific and Yukon Region.

Kendall, M.G. and Stuart, A. 1963. *The Advanced Theory of Statistics Vol. I.* (2nd ed.). Hafner Publishing Co.. N.Y.

Lewis, T. 1982. The Ecosystems of Tree-Farm License 24, Queen Charlotte Islands, B.C. 190p.

Lockley, R.M. 1953. Puffins. Doubleday and Co. Inc., New York.

Manuwal, D.A. 1974a. The natural history of Cassin's Auklet (*Ptychoramphus aleuticus*). Condor 76:421-431.

Manuwal, D.A. 1974b. Effects of territoriality on breeding in a population of Cassin's Auklet. Ecology 55:1399-1406.

Marshall, D.B. 1988. Status of the Marbled Murrelet in North America: with special emphasis on California, Oregon, and Washington. U.S. Fish Wildl. Serv.Biol. Rep. 88(30).19pp.

Nelson, S.K. 1989. Development of inventory techniques for surveying Marbled Murrelets (Brachyramphus marmoratus) in coniferous forests of the Oregon coast range. Unpubl. rept., Nongame Program, Oregon Dept. Fish Wildl., Publ. No. 88-6-01.

Nelson, S.K., McAllister, M.L.C., Stern, M.A. and Varoujean, D.H. 1987. Status of Marbled Murrelets in Oregon. Prepared for Pacific Seabird Group meetings, Dec. 1987. Unpub. report.

Paton, P.W.C., Ralph, C.J. and Carter, H.R. 1988. The Pacific Seabird Group's Marbled Murrelet survey and intensive inventory handbook. U.S. Forest Service

Paton, P.W.C. and Ralph, C.J. 1988. Geographic distribution of the Marbled Murrelet in California at inland sites during the 1988 breeding season. Unpbl. rept., California Dept. Fish Game, Sacramento, California.

Patterson, I.J. 1982. The Shelduck. Cambridge Univ. Press, London.

Pojar, J., Klinka, K. and Meidinger, D.V. 1987. Biogeoclimatic ecosystem classification in British Columbia. For. Ecol and Manage. 22:119-154.

Quinlan, S.E. and Hughes, J.H. 1984. Use of radio-tagging to locate Marbled Murrelet nest sites. Progress report covering 1 May 1983-30 June 1984. Alaska Dept. Fish Game.

Quinlan, S.E. and Hughes, J.H. 1990. Location and description of a Marbled Murrelet tree nest site in Alaska. Condor 92:1068-1073.

Ralph, C.J., Miller, S.L., Naslund, N.L., O'Donnell, B., Paton, P.W.C., and Seay, J. 1989. Marbled Murrelet research during 1989 in northern and central California. An interim report. U.S.D.A. Forest Service, Pacific Southwest Forest and Range Experimental Station. 50pp.

Reimchen, T.E. 1991. Marbled Murrelet habitat use in the Queen Charlotte Islands. In: M.S. Rodway, J-P.L. Savard and H.M. Regehr 1991. Habitat use and activity patterns of Marbled Murrelets at inland and at-sea sites in the Queen Charlotte Islands, British Columbia. Technical Report Series No. 122, Can. Wildl. Serv., Pacific and Yukon Region.

Reimchen, T.E., and S.D. Douglas. 1984. Seasonal and diurnal abundance of aquatic birds on the Drizzle Lake Reserve, Queen Charlotte Islands, British Columbia. Canadian Field-Naturalist 98:22-28.

Rodway, M.S. 1990. Status report on the Marbled Murrelet Brachyramphus marmoratus in Canada 1990. COSEWIC report 58pp.

Savard, J-P.S. 1988. Use of nest boxes by Barrow's Goldeneye: nesting success and effect on the breeding population. Wild. Soc. Bull. 16:125-132.

Sealy, S.G. 1974. Breeding phenology and clutch size in the Marbled Murrelet. Auk 91:10-23.

Sealy, S.G. 1976. Biology of nesting Ancient Murrelets. Condor 78:294-306.

Sealy, S.G., and Carter, H.R. 1984. At-sea distribution and nesting habitat of the Marbled Murrelet in British Columbia: problems in the conservation of a solitarily nesting seabird. Pp. 737-756 In Croxall, J.P., Evans, P.G.H. and Schreiber, R.W. (eds.). ICBP Technical Publication No. 2.

Simons, T.R. 1980. Discovery of a ground-nesting Marbled Murrelet. Condor 82(1):1-9.

Singer, S.W., Naslund, N.L., Singer, S.A. and Ralph, C.J. in prep. Discovery of two nests of the Marbled Murrelet.

Spies, T.and Franklin, J.F. 1988. Old-growth and forest dynamics in the Douglas-fir region of western Oregon and Washington. NAJ 8(3):190-201.

Thorensen, A.C. 1964. The breeding behaviour of the Cassin's Auklet. Condor 66:456-476.

Varoujean, D.H, Williams, W.A. and Warrick, D.R. 1989. Nest locations and nesting habitat of the Marbled Murrelet (Brachyramphus marmoratus) in coastal Oregon. Nongame Wildl. Program, Oregon Dept. Fish Wildl., Publ. No. 88-6-02.

Walmsely, M. G., Utzig, T. Vold, D. Moon, and J. van Barnveld, (eds.) 1980. Describing ecosystems in the field. B.C. Min. Env. RAB Tech. Pap.2., B.C. Min. For. Land Manage. Rep. No. 7, Victoria ,B.C.

Wilkinson, L. 1989. SYSTAT: The System for Statistics. Evanston, IL. SYSTAT, Inc.

Wilson, U.W. 1977. A study of the biology of the Rhinoceros Auklet on Protection Island, Washington. MSc. Thesis Univ. Washington, Washington. 97pp.

Appendix 1. Key to Marbled Murrelet fixed station detection record.

The observation period extends from 75 minutes before official sunrise to 45 minutes after official sunrise. If birds are still active, continue observations until 15 minutes have elapsed since the last detection. Note that times used are Pacific Standard Time (see Time below). Record date, observer(s), station location, percent cloud cover (0-100), precipitation (see bottom of form), and official sunrise (from the closest point given on the attached sunrise tables) on the top of the form. Fill in a line for each detection as follows:

Det. No. - Detection number: a detection is defined as a bird or a group of birds behaving in a similar manner at the same time. Record groups as they are first seen; eg., if a group of birds is initially detected together but then splits into smaller groups, record them as a single detection and note the behaviour of the separated groups; if separate flocks merge, record them as separate detections, noting their behaviour. More than one line can be used for a single detection to record the behaviour of separate groups. Notes made at the bottom of the form should be referenced to the detection number.

Time - Record the time birds are first detected. Use Pacific Standard Time as that is the time used on official sunrise tables. Subtract one hour from Daylight Saving Time to get Standard Time.

Initial direction - The direction from you that the birds are first seen or heard. Use true (map) bearings, not magnetic bearings. Record actual bearings or closest of eight compass points (N, NE, E, SE, S, SW, W, NW).

No. keer calls - Total number of keer calls heard from the bird or groups of birds involved in the detection. For more than 10 calls that become difficult to count, use "M" (multiple) or > number counted (eg. >26). Record "0" if no keer calls are heard (always fill in this column).

Alt. Voc. - Alternate vocalization. Number of calls different than normal keer calls.

Wings - Put a check if wing beats are heard.

Jet sound - Number of jet sounds heard ("murrelet power dives").

Number seen - Number of birds actually seen. Record "0" if none are seen (always fill in this column).

Total estimated - Number of birds estimated from calls, including those seen.

Flight paths - Use symbols listed on the bottom of the record form. If birds are circling, estimate the radius of the circle (use the notes section). If birds land, describe the location, including tree species and height from ground, and mark the tree at the end of the observation period. "Motionless" refers to a bird(s) heard calling repeatedly from the same location. Describe and mark the location if known.

Height - Lowest height (in meters) the bird(s) are observed. Use codes listed on the bottom of the record form unless more accurate estimates can be made. In treeless areas record height above ground.

Closest distance - Closest horizontal distance (in meters) from the observer to the bird(s). A bird flying directly overhead would have a horizontal distance of zero.

Flight direction - The final direction the bird(s) were heading. Use true (map) bearings, not magnetic bearings. Record actual bearings or closest of eight compass points (N, NE, E, SE, S, SW, W, NW).

Last column - Use Blank columns(s) or notes to record other observations that you think are important, or factors that may affect observations (eg. wind). Suggestions for modifying the record form are welcome.

MARBLED MURRELET FIXED STATION DETECTION RECORD Date:________________

Observer:__________________ Station:____________________ Pg__ of__

Percent cloud cover:____ Precipitation:____ Official sunrise:______

Det. No.	Time	Initial Direction	No. Keer Calls	Alt. Voc.	Wings	Jet sound	Number Seen	Total Estimated	Flightpath	Height	Closest Distance (m)	Flight Direction	

Precipitation: N=None, F=Fog, D=Drizzle, R=Rain
Flightpath: S=Straight, T=Turn, C=Circle, L=Land, M=Motionless, U=Unknown
Height: A= >10m Above treetop, B= <10m Above treetop, C=Below treetop,
E=Enter canopy, X=eXit canopy, U=Unknown

Notes:____

Appendix 2. Marbled Murrelet detections at Lagins Creek station 16, from May to July summarized weekly.

Date	Sunrise time	Cloud (%)	Precip[a]	Wind (kn)	Det. No.	Keer calls	Alt. voc.	No. s	Flightpath[b]			Height[c]			Detections within			Duration of activity
yeen									S	T	C	A	B	C	500 m	150 m	50 m	(min)
22-May	04:37	0	N	5 W	21	163	0	0	0	0	0	0	0	0	21	15	2	43
23-May	04:36	0	N	0	36	350	0	0	0	0	0	0	0	0	36	29	12	92
24-May	04:35	100	N	0	56	953	0	3	2	0	0	0	0	9	56	45	15	72
25-May	04:33	10	N	0	23	355	3	0	1	0	0	0	0	3	23	17	5	52
26-May	04:32	100	N	5 SE	38	542	0	0	3	0	0	0	0	5	38	35	12	56
				Total	174	2363	3	3	6	0	0	0	0	17	174	141	46	315
				Mean	35	473	1	1	1	0	0	0	0	3	35	28	9	63
				SD	14	300	1	1	1	0	0	0	0	4	14	13	5	19
29-May	04:29	100	D	U[d]	42	710	0	0	0	0	0	0	1	3	42	33	7	110
30-May	04:28	100	N	U	34	711	3	1	1	0	0	0	1	2	34	31	10	66
31-May	04:27	0	N	U	48	678	0	1	0	0	0	0	0	3	48	46	31	72
01-Jun	04:26	0	N	U	36	697	5	0	0	0	0	0	0	1	36	36	14	47
02-Jun	04:25	100	N	U	64	946	8	0	0	0	2	0	0	6	64	62	22	99
				Total	224	3742	16	2	1	0	2	0	2	15	224	208	84	394
				Mean	45	748	3	0	0	0	0	0	0	3	45	42	17	79
				SD	12	111	3	1	0	0	1	0	1	2	12	13	10	26
12-Jun	04:20	100	D	0	31	575	0	0	0	0	0	0	0	0	31	31	16	73
13-Jun	04:19	0	N	U	39	575	0	0	0	0	0	1	0	5	39	39	39	47
14-Jun	04:19	0	N	U	15	255	0	0	0	0	0	0	2	6	15	15	13	35
15-Jun	04:19	100	D	U	25	380	0	0	0	0	0	0	0	0	25	25	25	84
16-Jun	04:19	100	N	U	26	340	3	0	0	0	0	0	0	0	26	26	8	75
				Total	136	2125	3	0	0	0	0	1	2	11	136	136	101	314
				Mean	27	425	1	0	0	0	0	0	0	2	27	27	20	63
				SD	9	144	1	0	0	0	0	0	1	3	9	9	12	21
19-Jun	04:19	100	R	0	49	816	0	0	0	0	0	0	0	3	49	49	26	89
20-Jun	04:19	100	R	0	99	1946	6	1	0	0	1	0	0	8	99	99	50	127
21-Jun	04:19	100	R	U	47	440	10	37	20	1	6	7	4	4	46	46	32	84
22-Jun	04:20	100	N	U	29	235	1	9	12	2	0	0	2	6	29	24	15	96
23-Jun	04:20	100	R	U	28	351	0	6	8	1	3	5	1	0	28	25	8	70
				Total	252	3788	17	53	40	4	10	12	7	21	251	243	131	466
				Mean	50	758	3	11	8	1	2	2	1	4	50	49	26	93
				SD	29	699	4	15	8	1	3	3	2	3	29	30	16	21
11-Jul	04:34	100	N	0	56	711	0	8	16	1	0	0	2	1	56	20	7	72
12-Jul	04:35	100	N	0	56	534	0	54	34	4	4	11	19	2	55	43	37	92
13-Jul	04:36	50	N	0	45	753	0	19	15	2	2	3	7	0	45	26	12	76
14-Jul	04:37	100	N	0	57	987	25	24	12	3	4	4	11	0	57	41	22	70
				Total	214	2985	25	105	77	10	10	18	39	3	213	130	78	310
				Mean	54	746	6	26	19	3	3	5	10	1	53	33	20	78
				SD	6	186	13	20	10	1	2	5	7	1	6	11	13	10
18-Jul	04:43	0	N	0	63	1308	5	9	15	2	10	1	3	3	62	45	27	56
19-Jul	04:44	0	N	0	63	908	19	22	26	2	5	6	7	0	62	58	29	61
20-Jul	04:45	0	N	0	79	1347	36	6	12	1	11	0	1	1	78	64	24	62
21-Jul	04:47	0	N	0	74	1289	40	15	22	1	11	1	3	1	73	62	24	63
				Total	279	4852	100	52	75	6	37	8	14	5	275	229	104	242
				Mean	70	1213	25	13	19	2	9	2	4	1	69	57	26	61
				SD	8	205	16	7	6	1	3	3	3	1	8	9	2	3
24-Jul	04:51	0	O	0	88	1727	76	31	37	5	10	7	5	0	87	76	27	84
25-Jul	04:53	0	N	0	72	1466	50	24	28	2	10	0	10	0	72	49	32	70
26-Jul	04:54	100	N	0	88	1813	80	60	30	11	16	2	21	1	88	70	53	91
27-Jul	04:56	50	N	U	59	1242	40	20	24	3	6	2	7	0	59	39	24	84
28-Jul	04:57	0	F	U	81	1798	155	8	41	0	4	2	1	1	81	56	30	90
				Total	388	8046	401	143	160	21	46	13	44	2	387	290	166	419
				Mean	78	1609	80	29	32	4	9	3	9	0	77	58	33	84
				SD	12	248	45	19	7	4	5	3	8	1	12	15	11	8

a - Precipitation: N=None, F=Fog, R=Rain
b - Flightpath: S=Straight, T=Turn, C=Circle
c - Height: A= >10m above treetop, B= <10m above treetop, C=Below treetop
d - Unknown

Appendix 3. Marbled Murrelet detections at Phantom Creek station 12, from May to August summarized weekly.

Date	Sunrise time	Cloud (%)	Precip[a]	Wind (kn)	Det. No.	Keer calls	Alt. voc.	No. seen	Flightpath[b]			Height[c]			Detections within			Duration of activity (min)
									S	T	C	A	B	C	500 m	150 m	50 m	
07-May	05:01	90	N	U[d]	23	318	2	3	2	1	0	1	0	1	23	14	0	37
08-May	05:00	100	F	U	23	393	32	3	3	2	2	1	1	1	23	6	1	51
09-May	04:58	100	D	U	24	386	45	6	3	4	3	1	2	1	24	10	3	63
10-May	04:56	100	N	U	31	527	19	6	8	2	6	0	2	1	31	16	3	51
11-May	04:54	90	N	5	33	489	44	3	0	1	4	2	1	0	33	15	0	60
12-May	04:53	100	N	U	36	587	75	4	7	2	5	1	2	0	36	21	5	66
				Total	170	2700	217	25	23	12	20	6	8	4	170	82	12	328
				Mean	28	450	36	4	4	2	3	1	1	1	28	14	2	55
				SD	6	101	25	1	3	1	2	1	1	1	6	5	2	11
14-May	04:49	60	N	U	17	282	10	0	2	4	1	0	0	0	17	7	0	42
15-May	04:48	100	N	U	21	321	7	3	5	3	2	1	1	0	21	9	0	64
16-May	04:46	100	D	U	41	648	43	12	6	4	5	3	4	0	41	29	6	120
17-May	04:44	60	N	U	17	325	32	0	1	0	1	0	0	0	17	7	1	37
18-May	04:43	100	D	U	27	463	10	12	3	2	6	3	4	0	27	18	3	63
19-May	04:41	90	N	15 SE	21	260	25	5	1	4	2	2	0	0	21	8	1	54
				Total	144	2299	127	32	18	17	17	9	9	0	144	78	11	380
				Mean	24	383	21	5	3	3	3	2	2	0	24	13	2	63
				SD	9	148	15	6	2	2	2	1	2	0	9	9	2	30
21-May	04:39	100	N	U	33	272	10	18	9	5	7	9	4	5	33	23	14	82
22-May	04:37	0	N	U	35	322	65	18	3	2	13	4	9	3	35	23	15	63
23-May	04:36	100	N	U	24	191	30	10	3	5	3	4	0	4	24	17	7	65
24-May	04:35	98	N	U	19	209	10	4	4	0	2	1	2	0	19	10	3	53
25-May	04:33	10	N	U	19	264	10	4	2	2	1	0	2	0	19	15	0	71
26-May	04:32	50	N	15 SE	16	130	10	0	0	0	1	0	0	0	16	8	0	44
				Total	146	1388	135	54	21	14	27	18	17	12	146	96	39	378
				Mean	24	231	23	9	4	2	5	3	3	2	24	16	7	63
				SD	8	68	22	8	3	2	5	3	3	2	8	6	7	13
29-May	04:29	100	N	10 SE	32	537	0	4	7	2	5	7	0	0	32	16	4	83
30-May	04:28	25	N	0	40	759	15	0	2	3	8	5	0	0	40	21	4	80
31-May	04:27	0	N	0	29	516	15	2	6	1	7	3	1	1	29	14	5	68
01-Jun	04:26	0	N	0	21	342	20	0	8	0	4	3	1	0	21	10	0	43
02-Jun	04:25	100	D	15 SE	46	595	25	22	4	5	14	14	4	1	46	33	17	99
				Total	168	2749	75	28	27	11	38	32	6	2	168	93	30	373
				Mean	34	550	15	6	5	2	8	6	1	0	34	19	6	75
				SD	10	150	9	9	2	2	4	5	2	1	10	9	6	21
12-Jun	04:20	100	D	U	78	1430	50	27	23	6	21	12	2	0	77	49	19	150
13-Jun	04:19	0	N	0	42	559	25	11	18	2	9	5	3	5	42	24	13	68
14-Jun	04:19	0	N	5 W	35	538	25	10	8	2	9	1	3	7	35	18	12	68
15-Jun	04:19	100	D	0	82	975	85	55	24	7	23	16	8	9	82	57	31	146
16-Jun	04:19	100	D	0	48	864	25	12	12	0	11	8	4	0	45	25	10	123
				Total	285	4366	210	115	85	17	73	42	20	21	281	173	85	555
				Mean	57	873	42	23	17	3	15	8	4	4	56	35	17	111
				SD	22	365	26	19	7	3	7	6	2	4	22	17	9	41
27-Jun	04:22	100	R	U	92	963	25	73	27	1	30	19	6	16	93	69	28	154
28-Jun	04:22	0	N	U	56	508	5	28	9	1	19	3	5	16	56	42	29	50
29-Jun	04:23	100	D	0	48	550	0	15	10	3	8	14	2	4	48	23	15	67
30-Jun	04:23	100	N	0	78	1219		30	13	5	13	27	2	7	78	49	32	113
01-Jul	04:24	100	N	0	68	531	0	41	10	10	13	18	8	10	67	48	34	86
				Total	342	3771	30	187	69	20	83	81	23	53	342	231	138	470
				Mean	68	754	8	37	14	4	17	16	5	11	68	46	28	94
				SD	17	321	12	22	8	4	8	9	3	5	18	16	7	41
11-Jul	04:34	100	N	0	57	882	10	28	15	7	7	0	11	1	54	37	13	66
12-Jul	04:35	100	N	U	78	1644	75	28	21	5	11	11	2	0	78	41	22	85
13-Jul	04:36	100	D	0	106	1918	50	46	25	3	21	27	3	1	106	58	31	131
14-Jul	04:37	40	N	0	87	1420	30	48	14	1	18	16	4	3	87	48	18	103
				Total	328	5864	165	150	75	16	57	54	20	5	325	184	84	385
				Mean	82	1466	41	38	19	4	14	14	5	1	81	46	21	96
				SD	20	439	28	11	5	3	6	11	4	1	22	9	8	28
24-Jul	04:51	40	N	0	130	2064	142	113	36	5	24	17	10	4	123	94	57	100
25-Jul	04:53	40	N	0	100	1740	89	96	29	2	25	21	8	6	100	65	47	99
26-Jul	04:54	100	D	U	155	2429	183	183	28	8	47	53	4	7	150	97	61	150
27-Jul	04:56	1	N	0	42	725	17	7	7	4	1	3	2	3	42	19	10	101
28-Jul	04:57	0	N	U	46	626	15	21	4	5	11	3	4	3	46	28	19	61
				Total	473	7584	446	420	104	24	108	97	28	23	461	303	194	511
				Mean	95	1517	89	84	21	5	22	19	6	5	92	61	39	102
				SD	50	807	75	72	14	2	17	20	3	2	47	36	23	32

Appendix 3. (cont'd)

Date	Sunrise time	Cloud (%)	Precip[a]	Wind (kn)	Det. No.	Keer calls	Alt. voc.	No. seen	Flightpath[b]			Height[c]			Detections within			Durationof activity (min)
									S	T	C	A	B	C	500 m	150 m	50 m	
07-Aug	05:14	100	D	7 NW	28	256	0	15	0	1	4	9	9	0	24	18	0	98
08-Aug	05:16	95	N	U	19	44	0	1	1	0	0	16	0	0	19	13	4	61
09-Aug	05:17	100	N	7 NW	4	14	0	0	0	0	0	1	0	0	4	3	0	30
10-Aug	05:19	0	N	0	8	60	0	0	3	0	0	8	0	0	8	3	0	33
11-Aug	05:20	0	N	0	6	25	0	0	0	0	0	0	0	0	6	4	0	27
				Total	65	399	0	16	4	1	4	34	9	0	61	41	4	249
				Mean	13	80	0	3	1	0	1	7	2	0	12	8	1	50
				SD	10	100	0	7	1	0	2	7	4	0	9	7	2	30
21-Aug	05:38	70	N	0	14	124	0	0	0	0	0	1	2	0	14	8	1	22
23-Aug	05:41	100	N	U	6	17	0	0	0	0	0	0	0	0	6	1	0	15
				Total	20	141	0	0	0	0	0	1	2	0	20	9	1	37
				Mean	10	71	0	0	0	0	0	1	1	0	10	5	1	19
				SD	6	76	0	0	0	0	0	1	1	0	6	5	1	5

a - Precipitation: N=None, F=Fog, R=Rain
b - Flightpath: S=Straight, T=Turn, C=Circle -
c - Height: A= >10m above treetop, B= <10m above treetop, C=Below treetop
d - Unknown

Appendix 4. Means and distributions by month of the time of Marbled Murrelet detections relative to sunrise at Lagins Creek and Phantom Creek.

Lagins Creek

					Percentiles					
Month	Weather	Mean	SE	n	0	10	50	90	100	Range
May	cloud	-2.6	1.6	234	-42	-34	-6	30	68	110
	clear	-26.7	1.17	164	-59	-44	-27	-8	42	101
June	cloud	0.9	1.14	530	-61	-31.5	-2	38	91	152
	clear	-31.7	1.19	113	-55	-49	-31	-15	0	55
July	cloud	-9.2	1.17	338	-62	-38	-9	19.5	43	105
	clear	-21.1	0.83	543	-62	-46	-21	3	33	95

Matrix of pairwise comparison probabilities:

		May clear	cloudy	June clear	cloudy	July clear	cloudy
May	clear	1.000					
	cloudy	0.0000	1.000				
June	clear	0.011	0.0000	1.000			
	cloudy	0.0000	0.078	0.0000	1.000		
July	clear	0.0006	0.0000	0.0000	0.0000	1.000	
	cloudy	0.0000	0.0065	0.0000	0.0000	0.0000	1.000

Phantom Creek

					Percentiles					
Month	Weather	Mean	SE	n	0	10	50	90	100	Range
May	clear	-23.8	1.57	173	-67	-49	-26	6	30	97
	cloud	-13.5	1.15	388	-93	-39	-16	15.5	87	180
June	clear	-28.4	1.30	154	-70	-50	-27	-8	13	83
	cloud	4.4	1.43	541	-59	-37	0	52	104	163
July	clear	-10.9	1.21	405	-61	-44	-11	22	50	111
	cloud	6.9	1.64	396	-51	-35	1	56	102	153
Aug	clear	-39.25	1.64	28	-61	-50	-38.5	-31.5	-18	43
	cloud	-14.4	3.74	57	-52	-41	-22	34	55	107

Matrix of pairwise comparison probabilities:

		May clear	cloudy	June clear	cloudy	July clear	cloudy	August clear	cloudy
May	clear	1.000							
	cloudy	0.0000	1.000						
June	clear	0.1263	0.0000	1.000					
	cloudy	0.0000	0.0000	0.0000	1.000				
July	clear	0.0000	0.0491	0.0000	0.0000	1.000			
	cloudy	0.0000	0.0000	0.0000	0.2274	0.0000	1.000		
August	clear	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000	1.000	
	cloudy	0.0947	0.2114	0.0062	0.0000	0.1087	0.0000	0.0000	1.000

Appendix 5. Proportions of Marbled Murrelet visual detections at different heights, categorized by group size and vocalization.

Lagins Creek –July

Number of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	1	8	6	7	20	13	8	28	19	55
2	0	23	8	1	25	7	1	48	15	64
3	0	12	2	0	1	0	0	13	2	15
4	0	6	1	0	0	0	0	6	1	7
Total	1	49	17	8	46	20	9	95	37	141

Percent of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	1.8	14.5	10.9	12.7	36.4	23.6	14.5	50.9	34.5	39.0
2	0.0	35.9	12.5	1.6	39.1	10.9	1.6	75.0	23.4	45.4
3	0.0	80.0	13.3	0.0	6.7	0.0	0.0	86.7	13.3	10.6
4	0.0	85.7	14.3	0.0	0.0	0.0	0.0	85.7	14.3	5.0
Total	0.7	34.8	12.1	5.7	32.6	14.2	6.4	67.4	26.2	100.0

Phantom Creek - May

Number of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	3	11	11	9	13	20	12	24	31	67
2	2	5	11	2	5	4	4	10	15	29
3	0	0	1	0	0	0	0	0	1	1
4	0	1	1	0	0	0	0	1	1	2
5-7	0	0	0	0	0	0	0	0	0	0
Total	5	17	24	11	18	24	16	35	48	99
1	4.5	16.4	16.4	13.4	19.4	29.9	17.9	35.8	46.3	67.7
2	6.9	17.2	37.9	6.9	17.2	13.8	13.8	34.5	51.7	29.3
3	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	1.0
4	0.0	50.0	50.0	0.0	0.0	0.0	0.0	50.0	50.0	2.0
5-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	5.1	17.2	24.2	11.1	18.2	24.2	16.2	35.4	48.5	100.0

Phantom Creek - June

Number of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	2	3	6	50	21	16	52	24	22	98
2	0	2	13	20	13	10	20	15	23	58
3	2	1	8	0	0	0	2	1	8	11
4	0	1	4	0	0	0	0	1	4	5
5-7	0	0	1	0	0	0	0	0	1	1
Total	4	7	32	70	34	26	74	41	58	173

Percent of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	2.0	3.1	6.1	51.0	21.4	16.3	53.1	24.5	22.4	56.6
2	0.0	3.4	22.4	34.5	22.4	17.2	34.5	25.9	39.7	33.5
3	18.2	9.1	72.7	0.0	0.0	0.0	18.2	9.1	72.7	6.4
4	0.0	20.0	80.0	0.0	0.0	0.0	0.0	20.0	80.0	2.9
5-7	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.6
Total	2.3	4.0	18.5	40.5	19.7	15.0	42.8	23.7	33.5	100.0

Appendix 5. (cont'd)

Phantom Creek - July

Number of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	0	3	10	14	14	8	14	17	18	49
2	5	8	25	4	17	19	9	25	44	78
3	1	2	18	0	0	0	1	2	18	21
4	0	3	22	0	0	0	0	3	22	25
5-7	1	1	9	0	0	0	1	1	9	11
Total	7	17	84	18	31	27	25	48	111	184

Percent of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	0.0	6.1	20.4	28.6	28.6	16.3	28.6	34.7	36.7	26.6
2	6.4	10.3	32.1	5.1	21.8	24.4	11.5	32.1	56.4	42.4
3	4.8	9.5	85.7	0.0	0.0	0.0	4.8	9.5	85.7	11.4
4	0.0	12.0	88.0	0.0	0.0	0.0	0.0	12.0	88.0	13.6
5-7	9.1	9.1	81.8	0.0	0.0	0.0	9.1	9.1	81.8	6.0
Total	3.8	9.2	45.7	9.8	16.8	14.7	13.6	26.1	60.3	100.0

Phantom Creek - August

Number of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	0	0	1	0	0	0	0	0	1	1
2	0	0	3	0	0	1	0	0	4	4
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5-7	0	0	0	0	0	0	0	0	0	0
Total	0	0	4	0	0	1	0	0	5	5

1	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	20.0
2	0.0	0.0	75.0	0.0	0.0	25.0	0.0	0.0	100.0	80.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.0	0.0	80.0	0.0	0.0	20.0	0.0	0.0	100.0	100.0

Phantom Creek - All months

Number of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	5	17	28	73	48	44	78	65	72	215
2	7	15	52	26	35	34	33	50	86	169
3	3	3	27	0	0	0	3	3	27	33
4	0	5	27	0	0	0	0	5	27	32
5-7	1	1	10	0	0	0	1	1	10	12
Total	16	41	144	99	83	78	115	124	222	461

Percent of sightings

Group size	Calling			Silent			Total			All birds
	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	below tree-top	<10 m above tree-top	>10 m above tree-top	
1	2.3	7.9	13.0	34.0	22.3	20.5	36.3	30.2	33.5	46.6
2	4.1	8.9	30.8	15.4	20.7	20.1	19.5	29.6	50.9	36.7
3	9.1	9.1	81.8	0.0	0.0	0.0	9.1	9.1	81.8	7.2
4	0.0	15.6	84.4	0.0	0.0	0.0	0.0	15.6	84.4	6.9
5-7	8.3	8.3	83.3	0.0	0.0	0.0	8.3	8.3	83.3	2.6
Total	3.5	8.9	31.2	21.5	18.0	16.9	24.9	26.9	48.2	100.0

Appendix 6. Proportions of Marbled Murrelet visual detections with different flight behaviours, categorized by group size and vocalization.

Lagins Creek - July

Number of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	14	2	3	32	5	2	46	7	5	58
2	20	10	6	26	7	1	46	17	7	70
3	10	2	5	1	0	0	11	2	5	18
4	3	1	5	0	0	0	3	1	5	9
Total	47	15	19	59	12	3	106	27	22	155

Percent of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	24.1	3.4	5.2	55.2	8.6	3.4	79.3	12.1	8.6	37.4
2	28.6	14.3	8.6	37.1	10.0	1.4	65.7	24.3	10.0	45.2
3	55.6	11.1	27.8	5.6	0.0	0.0	61.1	11.1	27.8	11.6
4	33.3	11.1	55.6	0.0	0.0	0.0	33.3	11.1	55.6	5.8
Total	30.3	9.7	12.3	38.1	7.7	1.9	68.4	17.4	14.2	100.0

Phantom Creek - May

Number of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	9	4	11	19	8	15	28	12	26	66
2	5	5	8	2	3	6	7	8	14	29
3	0	0	1	0	0	0	0	0	1	1
4	0	1	1	0	0	0	0	1	1	2
5-7	0	0	0	0	0	0	0	0	0	0
Total	14	10	21	21	11	21	35	21	42	98

Percent of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	13.6	6.1	16.7	28.8	12.1	22.7	42.4	18.2	39.4	67.3
2	17.2	17.2	27.6	6.9	10.3	20.7	24.1	27.6	48.3	29.6
3	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0	1.0
4	0.0	50.0	50.0	0.0	0.0	0.0	0.0	50.0	50.0	2.0
5-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	14.3	10.2	21.4	21.4	11.2	21.4	35.7	21.4	42.9	100.0

Phantom Creek - June

Number of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	5	1	7	25	16	49	30	17	56	103
2	1	0	17	20	8	18	21	8	35	64
3	4	1	7	0	0	0	4	1	7	12
4	1	0	4	0	0	0	1	0	4	5
5-7	1	0	0	0	0	0	1	0	0	1
Total	12	2	35	45	24	67	57	26	102	185

Percent of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	4.9	1.0	6.8	24.3	15.5	47.6	29.1	16.5	54.4	55.7
2	1.6	0.0	26.6	31.3	12.5	28.1	32.8	12.5	54.7	34.6
3	33.3	8.3	58.3	0.0	0.0	0.0	33.3	8.3	58.3	6.5
4	20.0	0.0	80.0	0.0	0.0	0.0	20.0	0.0	80.0	2.7
5-7	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.5
Total	6.5	1.1	18.9	24.3	13.0	36.2	30.8	14.1	55.1	100.0

Appendix 6. (cont'd)

Phantom Creek - July

Number of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	10	2	8	14	8	20	24	10	28	62
2	17	2	29	21	7	22	38	9	51	98
3	8	3	20	0	0	0	8	3	20	31
4	14	7	14	0	0	0	14	7	14	35
5-7	4	3	6	0	0	0	4	3	6	13
Total	53	17	77	35	15	42	88	32	119	239

Percent of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	16.1	3.2	12.9	22.6	12.9	32.3	38.7	16.1	45.2	25.9
2	17.3	2.0	29.6	21.4	7.1	22.4	38.8	9.2	52.0	41.0
3	25.8	9.7	64.5	0.0	0.0	0.0	25.8	9.7	64.5	13.0
4	40.0	20.0	40.0	0.0	0.0	0.0	40.0	20.0	40.0	14.6
5-7	30.8	23.1	46.2	0.0	0.0	0.0	30.8	23.1	46.2	5.4
Total	22.2	7.1	32.2	14.6	6.3	17.6	36.8	13.4	49.8	100.0

Phantom Creek - August

Number of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	1	0	0	0	0	0	1	0	0	1
2	0	1	2	0	0	0	0	1	2	3
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5-7	0	0	1	0	0	0	0	0	1	1
Total	1	1	3	0	0	0	1	1	3	5

Percent of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	100.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	20.0
2	0.0	33.3	66.7	0.0	0.0	0.0	0.0	33.3	66.7	60.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5-7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Total	20.0	20.0	60.0	0.0	0.0	0.0	20.0	20.0	60.0	100.0

Phantom Creek - All months

Number of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	25	7	25	58	32	84	83	39	110	232
2	23	8	56	43	18	46	66	26	102	194
3	12	4	28	0	0	0	12	4	28	44
4	15	8	19	0	0	0	15	8	19	42
5-7	5	3	7	0	0	0	5	3	7	15
Total	80	30	136	101	50	130	181	80	266	527

Percent of sightings

Group size	Calling			Silent			Total			All Birds
	Straight	Turning	Circling	Straight	Turning	Circling	Straight	Turning	Circling	
1	10.8	3.0	11.2	25.0	13.8	36.2	35.8	16.8	47.4	44.0
2	11.9	4.1	28.9	22.2	9.3	23.7	34.0	13.4	52.6	36.8
3	27.3	9.1	63.6	0.0	0.0	0.0	27.3	9.1	63.6	8.3
4	35.7	19.0	45.2	0.0	0.0	0.0	35.7	19.0	45.2	8.0
5-7	33.3	20.0	46.7	0.0	0.0	0.0	33.3	20.0	46.7	2.8
Total	15.2	5.7	25.8	19.2	9.5	24.7	34.3	15.2	50.5	100.0

Appendix 7. Daily and seasonal abundance of Marbled Murrelets in Long Inlet. First surveys (T1) began 30 minutes after sunrise; subsequent surveys were conducted at two hour intervals. A dash indicates that surveys were not done.

	Survey times									
Date	T1	T2	T3	T4	T5	T6	T7	T8	Mean	Maximum
Number of birds										
May 16	28	23	85	46	30	36	21	28	37.1	85
17	48	108	65	55	-	34	35	31	53.7	108
18	53	117	76	98	65	56	48	52	70.6	117
19	31	23	33	-	22	-	-	-	27.3	33
Mean	40.0	67.8	64.8	66.3	39.0	42.0	34.7	37.0	47.2	85.8
29	10	19	39	87	31	20	25	41	34.0	87
30	27	48	42	9	12	25	13	73	31.1	73
31	32	31	13	5	-	20	21	28	21.4	32
June 1	15	20	7	10	-	12	9	23	13.7	23
Mean	21.0	29.5	25.3	27.8	21.5	19.3	17.0	41.3	25.1	53.8
12	14	20	32	9	9	2	-	9	13.6	32
13	12	13	10	0	4	4	5	10	7.3	13
14	12	10	8	8	13	-	13	2	9.4	13
15	7	16	5	8	5	4	2	2	6.1	16
Mean	11.3	14.8	13.8	6.3	7.8	3.3	6.7	5.8	9.1	18.5
28	13	21	45	9	-	6	10	31	19.3	45
29	-	-	40	31	35	32	33	24	32.5	40
30	-	-	-	-	-	18	27	67	37.3	67
July 1	27	45	44	21	-	7	26	13	26.1	45
Mean	20.0	33.0	43.0	20.3	35.0	15.8	24.0	33.8	28.8	49.3
11	50	71	81	54	-	18	40	31	49.3	81
12	52	65	57	35	-	24	15	49	42.4	65
13	64	75	71	42	-	75	54	36	59.6	75
14	25	58	-	-	-	-	-	-	41.5	58
Mean	47.8	67.3	69.7	43.7	-	39.0	36.3	38.7	48.2	69.8
24	36	86	74	23	-	-	39	72	55.0	86
25	45	65	-	-	-	-	45	56	52.8	65
26	34	71	78	60	-	51	33	63	55.7	78
27	53	-	-	-	-	34	45	32	41.0	53
Mean	42.0	74.0	76.0	41.5	-	42.5	40.5	55.8	51.1	70.5
MEAN	31.3	47.9	45.3	30.5	22.6	25.2	26.6	35.1	34.9	57.9

Appendix 7. (cont'd)

DATE	T1	T2	T3	T4	T5	T6	T7	T8
Percent of daily maximum								
May 16	33	27	100	54	35	42	25	33
17	44	100	60	51	-	31	32	29
18	45	100	65	84	56	48	41	44
19	94	70	100	-	67	-	-	-
29	11	22	45	100	36	23	29	47
30	37	66	58	12	16	34	18	100
31	100	97	41	16	-	63	66	88
June 1	65	87	30	43	-	52	39	100
12	44	63	100	28	28	6	-	28
13	92	100	77	0	31	31	38	77
14	92	77	62	62	100	-	100	15
15	44	100	31	50	31	25	13	13
28	29	47	100	20	-	13	22	69
29	-	-	100	78	88	80	83	60
30	-	-	-	-	-	27	40	100
July 1	60	100	98	47	-	16	58	29
11	62	88	100	67	-	22	49	38
12	80	100	88	54	-	37	23	75
13	85	100	95	56	-	100	72	48
14	43	100	-	-	-	-	-	-
24	42	100	86	27	-	-	45	84
25	69	100	0	0	-	-	69	86
26	44	91	100	77	-	65	42	81
27	100	-	-	-	-	64	85	60
Mean	59.8	82.5	73.1	46.2	48.7	41.1	47.1	59.3

Appendix 8. Marbled Murrelet distribution in Long Inlet from May to July 1990 (% of murrelets observed in a given section of the inlet).

Date	Head inlet	Second quarter	Third quarter	Mouth inlet
May 16	18.0	17.2	28.6	36.1
17	14.6	22.2	37.7	25.5
18	8.6	17.6	27.6	46.3
19	6.2	24.1	28.6	41.1
Mean ± SE	11.9±2.7	20.3±1.7	30.6±2.4	35.0±5.2
29	40.3	34.2	17.2	8.2
30	46.4	29.1	4.4	20.2
31	20.8	58.6	13.1	7.6
June 1	20.6	53.2	13.7	12.6
Mean ± SE	32.0±6.7	43.8±7.2	12.1±2.7	12.2±2.9
12	35.5	45.1	8.5	10.9
13	60.0	33.3	3.8	2.9
14	52.0	19.4	25.0	3.6
15	31.5	30.0	13.3	25.3
Mean ± SE	44.9±6.8	32.0±5.3	12.7±4.6	10.7±5.2
28	40.8	27.8	24.1	7.3
29	51.5	36.0	6.0	6.5
30	42.2	42.0	3.5	12.3
July 1	46.0	39.6	8.9	5.5
Mean ± SE	45.1±2.4	36.4±3.1	10.6±4.6	7.9±1.5
11	49.7	37.8	8.6	3.8
12	47.8	34.9	9.8	7.5
13	46.3	27.1	15.4	11.2
14	34.4	55.3	10.3	0.0
Mean ± SE	44.6±3.5	38.8±6.0	11.0±1.5	5.6±2.4
24	53.0	33.3	8.4	5.2
25	24.1	40.8	29.4	5.8
26	64.2	25.0	8.0	2.4
27 79.4	6.4	5.1	9.2	
Mean ± SE	55.2±11.3	26.4±7.4	12.7±5.6	5.7±1.4

Appendix 9. Mean daily and weekly numbers of Marbled Murrelets in Long Inlet and Shields Bay from May to July 1990.

	Long Inlet						Shields Bay		
	No. of surveys	Mean no. of birds	Max. no. of birds	No. with fishes	No. juv.	No. winter	Max. no. of birds	No. with fishes	No. young or winter plumage
May 4							40		
9							65		
14							11		
15							5		
16	8	37.1	85				5		
17	7	33.7	108				16		
18	8	70.6	117				25		
19	4	27.3	33				9		
		x=42.2±9.7	85.8±18.8				11.8±3.1		
28							13		
29		34.0	87				9		
30		31.1	73				29		
31		21.4	32				23		
June 1		13.7	23				7		
2							3		
		x=25.1±12.5	53.8±15.5				14.0±4.1		
11							1		
12		13.6	32		3		3	1	
13		7.3	13				3	2	
14		9.4	13				4	2	
15		6.1	16		1		3		
16							2		
		9.1±1.7	18.5±4.6				2.7±0.4		
26		19.3	45				6	1	
27		32.5	40				9		
28		37.3	67		1		3		
29		26.1	45		1		3		
30						1	8		
July 1					1	1	1		
		x=28.8±3.9	49.3±6.03				5.0±1.3		
11		49.3	81	1	1				
12		42.4	65			1			
13		59.4	75	1	1				
14		41.5	58						
		x=48.2±4.1	69.8±5.1						
23							2		
24		55.0	86	2	1	1	6		
25		52.8	65	1		1	10		2
26		55.7	78	1	2	1	1		
27		41.0	53	1			2	1	
28									
		x=51.1±3.4	70.5±7.3				4.2±1.7		

Appendix 10. Group size of Marbled Murrelet flocks in Long Inlet and Shields Bay in 1990. Data are from the maximum total count recorded on each date.

Date		Total no. of birds	No. of singles	No. of pairs	No. of groups >2	Ratio: single/ single+pairs
Long Inlet						
May	16	85	9	13	11	41
	17	108	16	19	11	46
	19	117	23	20	15	53
	19	33	1	11	3	8
		85.8±18.8	12.3±4.7	15.8±2.2	10.9±2.5	37.0±10
	29	87	1	14	6	7
	30	73	4	22	4	15
	31	32	4	14	0	22
June	1	23	2	9	1	18
		53.8±15.5	2.8±1.5	14.8±2.7	2.8±1.4	15.5±3.2
	11	10	2	4	0	33
	12	32	3	6	3	33
	13	13	2	2	2	50
	14	13	4	3	1	57
	15	16	4	2	2	67
		16.8±3.9	3.0±0.5	3.4±0.8	1.6±0.5	48.0±6.7
	28	45	4	7	5	36
	29	40	1	6	6	14
	30	67	2	18	6	10
July	1	45	4	13	3	24
		49.3±6.0	2.8±0.8	11.0±2.8	5.0±0.7	21.0±5.8
	11	81	3	22	6	12
	12	65	5	23	4	18
	13	75	6	22	4	21
	14	58	6	14	6	30
		69.8±5.1	5.0±0.7	20.3±2.1	5.0±0.6	20.3±3.8
	24	86	7	27	6	21
	25	65	3	17	8	15
	26	78	5	23	7	18
	27	53	5	18	3	22
		70.5±7.3	5.0±0.8	21.3±2.3	6.0±1.1	19.0±1.6

Appendix 10. (cont'd)

Date	Total no. of birds	No. of singles	No. of pairs	No. of groups >2	Ratio single/pairs
Shields Bay					
May 8	26	0	10	2	
14	11	1	5		17
15	5	1	2		33
16	5	3	1		75
17	16	0	3	2	0
18	25	1	8	2	11
19	9	1	4		20
x±se	6.0±3.1	1.9±0.4	3.8±1.0	0.7±0.4	26±10.8
28	13	0	1	1	0
29	9	2	1	1	67
30	29	0	8	3	0
31	23	3	6	1	33
June 1	7	0	0	1	-
2	3	0	0	1	-
x±se	14.0±4.09	0.8±0.5	2.7±1.4	1.3±0.3	25.0±16.0
11	1	1	0		100
12	3	3	0		100
13	3	1	1		50
14	4	2	1		66
15	3	3	0		100
16	2	2	0	0	100
x±se	2.7±0.4	2.0±0.4	0.3±0.2		86.0±9.1
26	6	4	1		80
27	9	3	3		50
28	3	1	1		50
29	3	1	1		50
30	8	2	0	1	50
July 1	1	1	0		100
x±se	5.0±1.3	2.0±0.5	1.0±0.5	0.2±0.2	66±9.4
23	2	0	1		0
25	6	0	3		0
26	10	2	4		33
27	1	1	0		100
28	2	2	0		100
x±se	4.2±1.7	1.0±0.5	1.6±0.8	0	46.6±22.6

Appendix 11. Summary of vegetation data sorted into vegetation groups from habitat plots surveyed in Lagins and Phantom creeks.

Vegetation summary table DIFFERENTIATED TABLE FOR MAMU DATA 10:04 A.M. NOV. 28, 1990
Differentiated by PRESENCE Page 1

Vegetation unit	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN
Number of plots	1	2	3	2	1	3	8
Species	Presence class and mean species significance						
Blechnum spicant	5 +.5	5 4.5	5 5.8	5 7.5	5 3.5	5 4.5	IV 4.0
Coptis asplenifolia	5 +.5	5 3.5	5 5.2	5 6.6	5 1.5	4 2.2	V 5.9
Hylocomium splendens	5 5.5	5 6.5	5 7.5	5 7.5	5 3.5	5 5.1	V 5.6
Rhizomnium glabrescens	5 1.5	5 5.5	5 3.6	5 6.5	5 6.5	5 6.7	V 6.3
Rhytidiadelphus loreus	5 7.5	5 6.5	5 7.5	5 8.0	5 5.5	5 6.1	V 7.4
Tsuga heterophylla	5 4.5	5 7.6	5 7.2	5 7.6	5 9.1	5 8.1	V 8.2
Vaccinium parvifolium	5 4.5	5 2.5	5 3.0	5 7.0	5 3.5	5 5.0	V 5.4
Listera cordata	5 3.5	5 5.5	5 5.1	5 4.8		4 4.0	V 3.9
Menziesia ferruginea	5 5.5	5 5.5	5 3.9	5 7.0		4 1.4	III 3.5
Pellia neesiana	5 1.5	3 +.0	5 3.0	5 4.5		4 1.0	V 3.5
Picea sitchensis	5 2.5	5 4.0	4 3.6	5 5.4		5 5.0	V 5.3
Poa sp. (dd)	5 8.5	3 +.0	5 2.6	5 3.0		4 3.2	V 3.7
Vaccinium ovalifolium	5 +.5	5 8.6	5 7.5	3 1.7			IV 4.0
Cornus canadensis	5 4.5	3 1.7	4 3.3	5 5.5		2 +.6	II +.6
Rubus pedatus	5 1.5	3 +.0	4 1.0	5 2.1			II +.3
Thuja plicata	5 7.5	5 3.8	4 5.8	5 4.8			I 1.9
Conocephalum conicum	5 +.5	5 4.5	4 4.5			5 5.3	V 4.2
Leucolepis menziesii	5 +.5	5 4.5	5 3.6			4 6.0	III 3.3
Chamaecyparis nootkatensis	5 4.5	5 5.1	5 4.4				
Dicranum scoparium (c)	5 1.5	3 +.0		3 1.0		4 2.3	III 1.2
Maianthemum dilatatum	5 2.5		5 2.8	5 2.5	5 1.5	5 2.3	V 3.5
Rubus spectabilis	5 +.5		5 2.0	5 3.1	5 1.5	5 1.0	V 3.0
Dodecatheon hendersonii (d,c)	5 8.5			3 1.0			
Veratrum viride (d,cd)	5 5.5			3 3.5			I +.0
Lycopodium clavatum (c)	5 9.5		2 1.3			2 +.0	IV 2.1
Adiantum pedatum (d,c)	5 4.5					2 1.3	
Caltha biflora (d,c)	5 1.5						
Caltha leptosepala (d,cd)	5 6.5						
Smilacina stellata (d,c)	5 2.5						
Moneses uniflora		5 1.5	5 3.2	5 3.8	5 3.5	5 1.7	V 2.8
Listera caurina		5 +.5	4 2.3	5 4.6	5 2.5	2 +.0	IV 2.3
Gymnocarpium dryopteris		5 6.9	5 6.1	5 5.5		4 5.3	V 7.7
Tiarella trifoliata		5 3.5	4 3.1	5 2.5		4 1.2	III 2.1
Kindbergia oregana		3 1.0	4 1.2		5 4.5	5 4.2	I +.0
Athyrium filix-femina		5 1.5	5 2.2			4 4.1	IV 2.7
Streptopus amplexifolius (dd)		3 3.5	2 3.1	5 8.0	5 3.5	4 1.2	V 3.6
POGOALP (c)		3 +.0	2 +.6	3 4.5		5 4.9	IV 3.8
Luzula parviflora (d,c)		5 1.5		3 2.7		2 +.6	II 1.4
Plagiothecium undulatum (dd)		5 2.5	2 2.1		5 5.5	5 2.7	II 1.2
Viola glabella		3 +.0	2 +.0				III 1.3
Rubus parviflorus		3 +.0					II +.0
Streptopus roseus (d,cd)		5 5.5	2 +.0				
Sphagnum girgensohnii			5 5.0	5 6.6		4 3.3	V 5.1
Lysichitum americanum			4 1.4	3 1.0			
Corallorhiza maculata			2 +.0	3 +.0			
Herbertus aduncus (d)				3 1.0			
Plagiomnium insigne (d)				3 1.0			I +.0
Tsuga mertensiana (d,c)				5 +.5			
Dryopteris expansa (c)			2 1.3		5 3.5	4 1.6	IV 1.6
Scapania bolanderi			2 1.3		5 3.5	5 3.2	III 1.7
Isothecium stoloniferum (c)					5 2.5	4 3.3	II +.0
Polystichum munitum			2 +.6		5 +.5	5 3.2	II +.0

Appendix 11 (cont'd)

Vegetation summary table DIFFERENTIATED TABLE FOR MAMU DATA
Differentiated by PRESENCE

10:04 A.M. NOV. 28, 1990
Page 2

Vegetation unit	ONE	TWO	THREE	FOUR	FIVE	SIX	SEVEN
Number of plots	1	2	3	2	1	3	8
Species	Presence class and mean species significance						
Pteridium aquilinum (d,c)					5 +.5	2 +.6	I +.0
Polytrichum juniperinum (d,c)						5 2.8	II +.0
GALITRI (d)							III 1.5
Osmorhiza chilensis						2 +.6	III 2.0
Prenanthes alata (d)							IV 1.1
Alnus rubra							I 3.4
Antitrichia curtipendula (ic)						2 +.0	
Disporum hookeri						2 +.0	I +.0
Galium aparine							I +.0
Heracleum lanatum							I +.0
Hookeria lucens (ic)			2 +.0				
Peltigera sp. (ic)						2 +.0	
Pogonatum contortum			2 3.1				I +.5
Prenanthes sagittata							I +.0
Rhytidiadelphus triquetrus (ic)						2 2.1	
Smilacina racemosa							I +.5
Tiarella unifoliata			2 1.0				II 1.0

Appendix 11 (cont'd)

DIAGNOSTIC TABLE FOR MURRELET HABITAT PLOTS 10:19 A.M. NOV. 26, 1990 PAGE 1

Vegetation unit		1		2		3		4		5		6		7	
			1		2		3		4		5		6		7
Number of plots	Diagnostic	2		4		6		4		2		6		16	
Vegetation units and species	value'	Presence class' and mean species significance'													
CW-CY-HW-SS ALLIANCE															
Chamaecyparis nootkatensis	(d)	5	4.5	5	5.1	V	4.4								
Cornus canadensis	(d)	5	4.5	3	1.7	IV	3.3	5	5.5			II	+.5	II	+.5
Leucolepis menziesii	(d)	5	+.5	5	4.5	V	3.6					IV	6.0	III	3.3
Listera cordata	(d,c)	5	3.5	5	5.5	V	5.1	5	4.8			IV	4.0	V	3.9
Menziesia ferruginea	(d,cd)	5	5.5	5	5.5	V	3.9	5	7.0			IV	1.4	III	3.5
Pellia neesiana	(d,c)	5	1.5	3	+.0	V	3.0	5	4.5			IV	1.0	V	3.5
Poa sp.	(d,cd)	5	8.5	3	+.0	V	2.5	5	3.0			IV	3.2	V	3.7
Rubus pedatus	(d)	5	1.5	3	+.0	IV	1.0	5	2.0					II	+.0
Thuja plicata	(d,cd)	5	7.5	5	3.8	IV	5.8	5	4.8					I	1.8
Tiarella trifoliata	(d)			5	3.5	IV	3.1	5	2.5			IV	1.1	III	2.0
Vaccinium ovalifolium	(d)	3	+.0	4	7.0	IV	6.1	3	1.7					IV	3.6
HW-SS ALLIANCE															
Dryopteris expansa	(d,c)					II	1.2			5	3.5	IV	1.5	IV	1.5
Scapania bolanderi	(d,c)					II	1.2			5	3.5	V	3.2	III	1.7
Streptopus amplexifolius	(d,c)			3	3.5	II	3.1	5	6.0	5	3.5	IV	1.1	V	3.5
HELLEBORE-MAIDENHAIR-MARIGOLD ASSOCIATION															
Adiantum pedatum	(d,c)	5	4.5									II	1.2		
Caltha biflora	(d,c)	5	1.5												
Caltha leptosepala	(d,cd)	5	6.5												
Dicranum scoparium	(d,c)	5	1.5	3	+.0			3	1.0			IV	2.3	III	1.1
Dodecatheon hendersonii	(d,c)	5	3.5					3	1.0						
Lycopodium clavatum	(d,c)	5	3.5			II	1.2					II	+.0	IV	2.1
Poa sp.	(dd)	5	8.5	3	+.0	V	2.5	5	3.0			IV	3.2	V	3.7
Smilacina stellata	(d,c)	5	2.5												
Thuja plicata	(dd)	5	7.5	5	3.8	IV	5.8	5	4.8					I	1.8
Veratrum viride	(d,cd)	5	5.5					3	3.5					I	+.0
BLUEBERRY ASSOCIAION															
Vaccinium membranaceum	(dd)	3	+.0	3	6.0	III	5.8							I	1.2
Vaccinium ovalifolium	(dd)	3	+.0	4	7.0	IV	6.1	3	1.7					IV	3.6
DEER FERN-SPHAGNUM ASSOCIATION															
Blechnum spicant	(dd)	5	+.5	5	4.5	V	5.8	5	7.5	5	3.5	V	4.5	IV	4.0
Corallorhiza maculata	(d)					II	+.0	3	+.0						
Herbertus aduncus	(d)							3	1.0						
Plagiomnium insigne	(d)							3	1.0					I	+.0
Sphagnum girgensohnii	(dd)					V	5.0	5	6.6			IV	3.3	V	5.1
Streptopus amplexifolius	(dd)			3	3.5	II	3.1	5	6.0	5	3.5	IV	1.1	V	3.5
Tsuga mertensiana	(d,c)							5	+.5						
TWISTED STALK-WOODRUSH SUBASSOCIATION															

Appendix II. (cont'd)
DIAGNOSTIC TABLE FOR MURRELET HABITAT PLOTS

10:19 A.M. NOV. 28, 1990 PAGE 2

Vegetation unit		1	2	3	4	5	6	7
Number of plots	Diagnostic	2	4	6	4	2	6	16
Vegetation units and species	value[1]	Presence class[2] and mean species significance[3]						
Dicranum scoparium	(d)	5 1.5	3 +.0		3 1.0		IV 2.3	III 1.1
Luzula parviflora	(d,c)		5 1.5		3 2.7		II +.5	II 1.4
Plagiothecium undulatum	(d,c)		5 2.5	II 2.1		5 5.5	V 2.7	II 1.1
Rubus parviflorus	(d)		3 +.0					II +.0
Streptopus roseus	(d,cd)		5 5.5	II +.0				
CW-SKUNK CABBAGE SUBASSOCIATION								
Lysichitum americanum	(d)			IV 1.4	3 1.0			
Maianthemum dilatatum	(d,c)	5 2.5		V 2.8	5 2.5	5 1.5	V 2.2	V 3.5
Pellia neesiana	(d,c)	5 1.5	3 +.0	V 3.0	5 4.5		IV 1.0	V 3.5
Poa sp.	(d,c)	5 8.5	3 +.0	V 2.5	5 3.0		IV 3.2	V 3.7
Rubus spectabilis	(d,c)	5 +.5		V 2.0	5 3.1	5 1.5	V 1.0	V 3.0
Sphagnum girgensohnii	(d,cd)			V 5.0	5 6.6		IV 3.3	V 5.1
Thuja plicata	(dd)	5 7.5	5 3.8	IV 5.8	5 4.8			I 1.8
HW-MOSS (COLLUVIAL) ASSOCIATION								
Isothecium stoloniferum	(d,c)					5 2.5	IV 3.3	II +.0
Kindbergia oregana	(d,c)		3 1.0	IV 1.1		5 4.5	V 4.2	I +.0
Plagiothecium undulatum	(dd,cd)		5 2.5	II 2.1		5 5.5	V 2.7	II 1.1
Pteridium aquilinum	(d,c)					5 +.5	II +.5	I +.0
SS-HW-POGONATUM ASSOCIATION								
POGOALP	(d,c)		3 +.0	II +.5	3 4.5		V 4.3	IV 3.8
SS-HW-MOSS SUBASSOCIATION								
Isothecium stoloniferum	(d)					5 2.5	IV 3.3	II +.0
Kindbergia oregana	(d,c)		3 1.0	IV 1.1		5 4.5	V 4.2	I +.0
Leucolepis menziesii	(dd)	5 +.5	5 4.5	V 3.6			IV 6.0	III 3.3
Plagiothecium undulatum	(d,c)		5 2.5	II 2.1		5 5.5	V 2.7	II 1.1
Polytrichum juniperinum	(d,c)						V 2.8	II +.0
Polystichum munitum	(d,c)			II +.5		5 +.5	V 3.2	II +.0
Scapania bolanderi	(d,c)			II 1.2		5 3.5	V 3.2	III 1.7
SS-HW-HERB (ALLUVIAL) SUBASSOCATION								
Coptis aspleniifolia	(dd,cd)	5 +.5	5 3.5	V 5.2	5 6.6	5 1.5	IV 2.1	V 5.9
GALITRI	(d)							III 1.4
Gymnocarpium dryopteris	(dd,cd)		5 6.9	V 6.1	5 5.5		IV 5.3	V 7.7
Listera caurina	(d)		5 +.5	IV 2.3	5 4.6	5 2.5	II +.0	IV 2.2
Lycopodium clavatum	(d)	5 3.5		II 1.2			II +.0	IV 2.1
Prenanthes alata	(d)							IV 1.0
Vaccinium ovalifolium	(d)	3 +.0	4 7.0	IV 6.1	3 1.7			IV 3.6
Viola glabella	(d)		3 +.0	II +.0				III 1.2

---

[1] Species diagnostic values: d - differential, dd - dominant differential, cd - constant

Appendix 11 (cont'd)

dominant, c - constant, ic - important companion (Pojar et al. 1987).

'Presence classes as percent of frequency: I = 1-20, II = 21-40, III = 41-60, IV = 61-80, V = 81-100. If 5 plots or less, presence class is arabic value (1-5).

'Species significance class midpoint percent cover and range: + = 0.2 (0.1 - 0.3), 1 = 0.7 (0.4 - 1.0), 2 = 1.6 (1.1 - 2.1), 3 = 3.6 (2.2 - 5.0), 4 = 7.5 (5.1 - 10.0), 5 = 15.0 (10.1 - 20.0), 6 = 26.5 (20.1 - 33.0), 7 = 41.5 (33.1 - 50.0), 8 = 60.0 (50.1 - 70.0), 9 = 85.0 (70.1 - 100).

Appendix 12. Tukey HSD multiple comparisons of mean dbh amongst site associations and vegetation groups in Lagins Creek study area: matrix of pairwise comparison probabilities.

Site associations:

	CwSs-F	CwSs-C	HwSs-L	CwSs-Sk
CwSs-F	1.000			
CwSs-C	0.000	1.000		
HwSs-L	0.000	0.786	1.000	
CwSs-Sk	0.000	0.000	0.000	1.000

Vegetation groups:

	1	2	3	4	5	6	7
1	1.000						
2	0.000	1.000					
3	0.087	0.007	1.000				
4	0.000	1.000	0.010	1.000			
5	0.000	0.994	0.000	0.996	1.000		
6	0.000	0.708	0.000	0.759	0.998	1.000	
7	0.000	0.001	0.000	0.002	0.023	0.031	1.000

Appendix 13. Marbled Murrelet detections at stations in low and high elevation old-growth forest and alpine habitat at Lagins Creek, 1990. Site associations are from Banner et al. 1990. See Appendix II for explanation of coding for vegetation groups.

Station	Habitat Elev.	Site	Veg. assoc. group	Date	Sunrise time	Cloud (%)	Precip[a]	Wind (kn)	No. det.	Keer calls	Alt. voc.	No. seen	Flightpath[b] S	T	C	Height[c] A	B	C	Detections within 500 m	150m	50 m
7	Low	CwSs-F	7	19-May	04:41	100	N	15 SE	36	307	0	0	0	0	0	34	2	0	36	3	1
7	Low	CwSs-F	7	24-Jul	04:51	0	N	0	26	552	25	0	4	0	1	0	2	0	26	10	5
8	Low	CwSs-F	7	16-May	04:46	100	N	0	18	163	0	1	2	0	10	0	16	1	18	10	10
8	Low	CwSs-F	7	12-Jun	04:20	100	D	0	13	203	0	0	0	0	0	0	0	0	13	0	0
8	Low	CwSs-F	7	24-Jul	04:51	2	N	0	20	259	0	0	4	0	3	11	3	0	20	11	7
16	Low	CwSs-F	7	23-May	04:36	0	N	0	36	350	0	0	0	0	0	0	0	0	36	29	12
16	Low	CwSs-F	7	12-Jun	04:20	100	D	0	31	575	0	0	0	0	0	0	0	0	31	31	16
16	Low	CwSs-F	7	18-Jul	04:43	0	N	0	63	1308	5	9	15	2	10	1	3	3	62	45	27
17	Low	CwSs-C	7	22-May	04:37	0	N	0	11	89	0	0	1	0	0	5	4	0	11	3	2
17	Low	CwSs-C	7	19-Jun	04:19	100	R	0	37	630	0	3	3	1	3	1	0	2	36	18	8
17	Low	CwSs-C	7	14-Jul	04:37	75	N	0	45	685	15	9	5	4	5	3	0	1	45	23	9
18	Low	CwSs-C	7	22-May	04:37	0	N	0	7	20	0		1	0	1	6	0	0	7	0	0
18	Low	CwSs-C	7	19-Jun	04:19	100	R	0	8	39	0	0	0	1	0	0	0	0	8	1	0
18	Low	CwSs-C	7	21-Jul	04:47	0	N	0	62	1395	150	1	1	0	16	0	1	0	62	55	10
21	Low	CwSs-C	7	24-May	04:35	100	N	0	53	851	15	0	5	0	24	26	2	0	51	25	3
21	Low	CwSs-C	7	20-Jun	04:19	100	R	0	55	1350	20	2	20	2	8	4	0	0	53	39	16
21	Low	CwSs-C	7	19-Jul	04:44	50	N	0	45	869	10	0	0	0	9	0	0	0	41	32	21
25	Low	CwSs-C	7	26-May	04:32	90	N	5 SE	42	727	3	0	3	0	14	23	1	0	41	6	0
25	Low	CwSs-C	7	25-Jul	04:53	2	N	0	40	828	87	0	4	1	7	0	0	0	40	19	3
9	Low	CwSs-Sk	3	16-May	04:46	100	N	0	24	213	0	0	0	2	1	1	0	0	24	10	3
9	Low	CwSs-Sk	3	12-Jun	04:20	100	D	0	5	59	0	0	0	1	0	0	0	0	5	0	0
9	Low	CwSs-Sk	3	24-Jul	04:51	0	N	0	20	424	3	0	0	3	6	3	0	0	20	9	3
23	Low	PlYc-S	N/A	25-May	04:33	50	N	0	12	202	15	0	0	1	0	0	0	0	6	1	0
23	Low	PlYc-S	N/A	26-Jul	04:54	100	N	0	89	1737	99	65	11	11	13	19	1	0	89	55	15
24	Low	PlYc-S	N/A	25-May	04:33	30	N	0	36	588	10	0	0	0	14	15	2	11	36	5	1
24	Low	PlYc-S	N/A	28-Jul	04:57	0	N	0	54	1063	54	11	6	4	14	2	0	0	54	36	9
								Total	888	15486	511	101	85	33	159	154	37	18	871	476	181
								Mean	34	596	20	4	3	1	6	6	1	1	34	18	7
								SD	21	472	37	13	5	2	7	10	3	2	21	17	7

Appendix 13. (cont'd)

Station	Habitat		Veg. group	Date	Sunrise time	Cloud (%)	Precip[a]	Wind (kn)	No. det.	Keer calls	Alt. voc.	No. seen	Flightpath[b]			Height[c]			Detections within		
	Elev.	Site assoc.											S	T	C	A	B	C	500 m	150 m	50 m
22	High	HwSs-L	6	24-May	04:35	100	N	0	26	268	0	0	0	0	0	0	0	0	18	0	0
22	High	HwSs-L	6	20-Jun	04:19	100	F	0	49	670	10	0	2	1	1	3	0	0	48	1	1
22	High	HwSs-L	6	20-Jul	04:45	0	N	0	57	1052	50	0	0	0	20	0	0	0	55	35	2
26	High	HwSs-L	6	26-May	04:32	100	N	0	25	300	0	0	1	1	1	0	0	0	23	0	0
15	High	CwSs-Sk	3	19-May	04:41	100	D	15 SE	14	420	0	0	0	0	5	0	0	0	14	2	1
15	High	CwSs-Sk	3	16-Jun	04:19	100	N	15 NW	9	88	0	0	0	0	0	0	1	0	9	1	1
15	High	CwSs-Sk	3	25-Jul	04:53	0	N	0	15	207	0	0	5	0	3	1	0	0	14	4	0
19	High	CwSs-Sk	3	23-May	04:36	40	N	0	21	220	0	0	0	1	1	5	0	0	21	0	0
19	High	CwSs-Sk	3	21-Jul	04:47	0	N	0	34	381	15	0	8	0	7	17	0	0	22	6	5
20	High	CwSs-Sk	1	23-May	04:36	40	N	0	15	201	0	0	4	0	2	7	6	0	8	0	0
20	High	CwSs-Sk	1	21-Jul	04:47	0	N	0	39	543	15	2	2	1	2	1	0	0	39	14	3
35	High	CwSs-Sk	3	26-May	04:32	90	N	0	4	52	0	0	0	0	1	1	0	0	4	0	0
35	High	CwSs-Sk	3	20-Jul	04:45	0	N	5 NW	9	211	8	0	0	0	0	0	0	0	0	0	0
27	High	CwHw-B	N/A	22-May	04:37	0	N	0	5	78	0	0	1	0	0	0	0	0	5	0	0
27	High	CwHw-B	N/A	19-Jun	04:19	100	D	0	23	385	5	3	3	1	1	6	1	0	11	4	2
27	High	CwHw-B	N/A	21-Jul	04:47	0	N	0	6	100	0	0	0	0	1	0	0	0	3	0	0
28	High	CwHw-B	N/A	22-May	04:37	0	N	0	9	132	0	0	2	0	1	0	0	0	6	1	0
28	High	CwHw-B	N/A	19-Jun	04:19	100	R	0	11	157	0	0	0	0	1	6	0	0	11	0	0
28	High	CwHw-B	N/A	21-Jul	04:47	0	N	0	10	200	0	0	6	0	0	0	0	0	2	0	0
36	High	PlYc-S	N/A	26-May	04:32	100	N	0	1	25	0	0	1	0	0	0	0	0	1	0	0
36	High	PlYc-S	N/A	20-Jul	04:45	0	N	5 NW	13	286	5	3	1	0	0	0	1	0	9	3	0
14	High	PlYc-S	N/A	19-May	04:41	100	F	15 S	8	139	0	0	0	0	2	0	7	0	8	1	0
14	High	PlYc-S	N/A	16-Jun	04:19	100	N	10 NW	7	74	0	1	0	0	0	0	1	1	2	2	2
14	High	PlYc-S	N/A	25-Jul	04:53	0	N	0	11	364	26	7	1	2	3	10	1	0	10	1	1
							Total		421	6553	134	16	37	7	52	57	18	1	343	75	18
							Mean		18	273	6	1	2	0	2	2	1	0	14	3	1
							SD		14	230	12	2	2	1	4	4	2	0	15	7	1

Appendix 13. (cont'd)

Station	Elev.	Habitat Site assoc.	Veg. group	Date	Sunrise time	Cloud (%)	Precip[a]	Wind (kn)	No. det.	Keer calls	Alt. voc.	No. seen	Flightpath[b]			Height[c]			Detections within		
													S	T	C	A	B	C	500 m	150 m	50 m
10	Alpine	HmYc-Mh	N/A	17-May	04:44	0	N	10 N	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Alpine	HmYc-Mh	N/A	13-Jun	04:19	0	N	12 NW	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Alpine	HmYc-Mh	N/A	17-May	04:44	0	N	10 N	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Alpine	HmYc-Mh	N/A	13-Jun	04:19	0	N	12 NW	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Alpine	HmYc-Mh	N/A	18-May	04:43	100	F	10 NW	13	207	0	0	0	0	9	0	0	0	0	0	0
12	Alpine	HmYc-Mh	N/A	14-Jun	04:19	20	N	7 NW	0	0	0	0	0	0	0	0	0	0	0	0	0
12	Alpine	HmYc-Mh	N/A	13-Jul	04:36	100	F	7 NW	4	91	1	0	0	0	1	0	0	0	0	0	0
13	Alpine	HmYc-Mh	N/A	18-May	04:43	100	F	5 NW	2	50	0	0	0	0	0	0	0	0	0	0	0
13	Alpine	HmYc-Mh	N/A	14-Jun	04:19	10	N	3 NW	0	0	0	0	0	0	0	0	0	0	0	0	0
13	Alpine	HmYc-Mh	N/A	14-Jul	04:37	80	N	7 SW	4	47	0	0	0	0	0	0	0	0	0	0	0
29	Alpine	HmYc-Mh	N/A	23-May	04:36	20	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	Alpine	HmYc-Mh	N/A	20-Jun	04:19	100	F	22 SE	2	50	3	0	0	0	0	0	0	0	1	0	0
29	Alpine	HmYc-Mh	N/A	19-Jul	04:44	20	N	7 NW	12	207	0	0	0	0	0	0	0	0	4	0	0
30	Alpine	HmYc-Mh	N/A	23-May	04:36	25	N	10 SW	5	114	0	0	0	0	1	0	0	0	0	0	0
30	Alpine	HmYc-Mh	N/A	20-Jun	04:19	100	F	15 SE	2	32	15	0	0	0	1	0	0	0	0	0	0
30	Alpine	HmYc-Mh	N/A	19-Jul	04:44	5	N	7 NW	4	54	0	0	0	0	0	0	0	0	0	0	0
31	Alpine	HmYc-Mh	N/A	24-May	04:35	100	F	15 S	0	0	0	0	0	0	0	0	0	0	0	0	0
31	Alpine	HmYc-Mh	N/A	22-Jun	04:19	100	F	10 SW	2	33	5	0	0	0	1	1	0	0	1	0	0
31	Alpine	HmYc-Mh	N/A	18-Jul	04:43	2	N	0	3	15	0	0	0	0	0	0	0	0	1	0	0
32	Alpine	HmYc-Mh	N/A	24-May	04:35	100	F	15 SE	2	49	0	0	0	0	0	0	0	0	0	0	0
32	Alpine	HmYc-Mh	N/A	22-Jun	04:20	90	F	15 SW	7	74	5	5	0	2	0	2	0	0	2	2	2
32	Alpine	HmYc-Mh	N/A	18-Jul	04:43	10	N	5 NW	4	34	0	0	0	2	0	0	0	0	1	1	1
33	Alpine	HmYc-Mh	N/A	25-May	04:33	20	N	20 SE	2	86	0	0	0	0	0	0	0	0	0	0	0
33	Alpine	HmYc-Mh	N/A	18-Jul	04:43	0	N	5 NW	5	69	5	2	0	1	0	0	0	0	3	1	1
34	Alpine	HmYc-Mh	N/A	25-May	04:33	20	N	15 SE	2	50	0	0	0	0	1	0	0	0	0	0	0
34	Alpine	HmYc-Mh	N/A	18-Jul	04:43	0	N	5 NW	4	62	6	0	0	0	0	0	0	0	0	0	0
								Total	79	1324	40	7	0	5	14	3	0	0	13	4	4
								Mean	3	51	2	0	0	0	1	0	0	0	1	0	0
								SD	3	56	3	1	0	1	2	0	0	0	1	0	0

a - Precipitation: N=None, F=Fog, R=Rain

b - Flightpath: S=Straight, T=Turn, C=Circle

c - Height: A= >10m above treetop, B= <10m above treetop, C=Below treetop

Appendix 14. Marbled murrelet detections at inland locations surveyed outside the main study area from May to July 1990. Locations are listed alphabetically (see Fig. 1 for locations).

Station	Date	Sunrise time	Cloud (%)	Precip	Wind (kn)	No. Det.	Keer calls	Alt. Voc.	No. seen	Flightpath S	Flightpath T	Flightpath C	Height A	Height B	Height C	Detections within 500 m	Detections within 150 m	Detections within 50 m
BREAKER BAY #1	31-Jul	05:02	90	F	0	63	1211	55	0	0	0	15	0	0	0	63	5	0
#2	31-Jul	05:02	100	N	0	59	1337	62	22	4	1	43	38	1	0	59	25	7
DEENA RIVER #1	18-Jul	04:43	0	N	U	54	623	45	11	3	0	0	53	0	1	54	33	15
#2	27-Jul	04:56	100	N	22 U	11	682	0	1	16	0	24	23	1	32	27	8	1
GOVERNMENT CREEK #1	10-Jul	04:33	100	R	20 W	75	509	4	80	15	15	14	3	35	6	75	61	29
#2	11-Jul	04:34	100	N	0	94	823	32	113	27	21	21	25	33	29	94	92	76
#3	11-Jul	04:34	100	N	U	55	687	0	32	6	1	12	41	14	0	54	27	7
#4	12-Jul	04:35	100	N	0	124	1050	2	182	29	53	25	42	26	50	124	124	115
#5	12-Jul	04:35	100	N	0	50	414	0	57	29	2	6	28	13	9	50	34	16
#6	12-Jul	04:35	100	N	0	66	828	6	12	9	4	1	10	55	1	66	46	6
GRAY BAY #1	29-May	04:29	100	N	10 SE	0												
#2	29-May	04:29	100	N	5 SE	0												
#3	04-Jul	04:27	95	N	U	4	60	0	0	0	0	0	0	0	0	4	2	2
#4	04-Jul	04:27	90	N	U	1	25	0	0	0	0	0	0	0	0	1	1	1
#5	05-Jul	04:28	0	N	U	2	50	0	0	0	0	0	0	0	0	2	1	0
#6	05-Jul	04:28	0	N	U	1	1	0	0	0	0	0	0	0	0	1	1	0
#7	06-Jul	04:24	98	N	0	0												
#8	06-Jul	04:29	98	N	U	5	75	0	2	1	0	1	2	0	0	5	5	3
#9	07-Jul	04:29	100	N	U	1	15	0	0	0	0	0	0	0	0	1	1	1
#10	07-Jul	04:29	100	N	0	0												
HANGOVER CREEK	26-Apr	05:23	100	R	0	13	53	0	8	0	3	0	3	3	0	13	2	1
HONNA RIVER	14-May	04:49	0	N	U	18	230	10	4	0	1	0	4	0	0	18	6	4
IAN LAKE #1	26-Jul	04:54	80	N	0	30	378	0	7	3	2	11	8	0	0	18	7	7
#2	26-Jul	04:54	100	N	0	43	564	33	28	7	6	8	8	8	4	43	35	18
#3	27-Jul	04:56	90	N	2 NE	74	1166	18	13	27	2	6	28	0	0	57	31	16
#4	27-Jul	04:56	99	N	2 NE	56	1171	209	26	9	2	37	48	0	6	48	16	11
#5	28-Jul	04:57	2	N	U	76	1458	189	75	20	6	28	31	7	5	75	61	46
EVENING: #1	26-Jul	20:53	U	U	U	1	25	0	0	0	0	0	0	0	0	1	1	1
#3	26-Jul	20:53	U	N	U	6	107	0	0	3	0	0	5	0	0	5	2	1
#5	27-Jul	20:51	U	U	U	2	25	0	0	2	0	0	0	1	0	1	1	1
JUNGLE CREEK #1	26-Jul	04:54	0	N	0	0												
#2	30-Jul	05:01	0	N	0	0												
#3	30-Jul	05:01	0	N	0	0												

Appendix 14. (cont'd)

Station	Date	Sunrise time	Cloud (%)	Precip	Wind (kn)	No. Det.	Keer calls	Alt. Voc.	No. seen	Flightpath			Height			Detections within		
										S	T	C	A	B	C	500 m	150 m	50 m
MERCER LAKE #1	04-Jul	04:27	0	N	U	60	697	0	0	30	6	6	27	13	2	54	19	8
#2	04-Jul	04:27	0	N	U	28	377	10	1	3	3	3	22	0	0	28	23	11
#3	05-Jul	04:28	0	N	U	54	947	12	3	26	2	7	38	12	1	52	21	8
#4	05-Jul	04:28	0	N	U	38	404	20	0	18	2	3	24	0	0	38	16	6
#5	06-Jul	04:29	85	N	U	45	703	0	0	22	0	4	30	10	0	34	6	1
#6	06-Jul	04:29	0	N	U	30	479	10	0	8	2	0	0	0	0	20	0	0
#7	07-Jul	04:29	100	F	U	13	178	0	0	8	0	1	10	1	0	1	1	1
#8	07-Jul	04:29	100	F	U	17	153	15	0	3	0	2	0	0	0	4	0	0
NAIKOON PARK #1	31-May	04:27	100	N	5 NW	42	661	0	15	12	0	7	0	21	12	42	35	23
#2	31-May	04:27	100	N	20 W	13	184	0	0	0	0	2	0	0	0	13	0	0
#3	01-Jun	04:26	100	N	0	7	150	0	0	0	1	1	0	0	1	7	5	2
#4	01-Jun	04:26	100	N	0	51	958	90	3	1	0	11	12	9	0	51	44	33
#5	02-Jun	04:25	40	N	10 SE	29	312	0	13	8	0	4	7	10	4	29	25	24
#6	02-Jun	04:25	100	N	5 SE	40	173	0	33	3	21	4	8	8	20	40	40	27
#6	06-Jul	04:29	0	N	0	44	220	18	48	19	13	4	3	16	25	44	42	32
#7	07-Jul	04:29	100	N	0	18	295	0	5	2	0	2	0	3	0	18	9	6
PHANTOM CREEK #1	30-Apr	05:15	30	N	10 W	2	7	0	0	0	0	0	0	0	2	2	0	0
#2	30-Apr	05:15	30	N	10 W	1	2	0	0	0	0	0	0	0	0	1	0	0
#3	30-Apr	05:15	30	F	10 NW	26	182	3	0	1	0	0	0	1	1	26	3	1
#3	01-May	05:13	100	F	0	41	205	0	4	3	2	1	0	2	1	41	5	1
#3	14-May	04:49	80	N	20 NW	11	143	0	0	2	0	5	0	11	0	11	1	0
#4	01-May	05:13	100	F	0	3	32	0	0	0	0	0	0	0	0	3	0	0
#5	01-May	05:13	100	F	0	20	258	5	4	0	1	0	11	0	1	20	14	5
#5	02-May	05:11	100	D	0	31	252	0	8	5	2	3	0	10	0	31	19	5
#5	01-Jul	04:24	100	N	U	35	268	0	20	11	3	2	10	1	0	35	19	16
#6	02-May	05:11	100	F	0	11	88	0	0	0	0	0	0	0	0	11	0	0
#7	02-May	05:11	100	F	0	29	360	0	10	4	4	1	5	1	2	29	26	3
#7	04-May	05:07	100	D	0	25	106	3	13	6	4	1	3	3	3	25	13	6
#8	03-May	05:09	90	F	5	14	152	0	4	3	0	2	7	5	1	14	8	1
#9	03-May	05:09	99	N	0	1	0	0	2	0	1	0	1	0	0	1	0	0
#10	03-May	05:09	100	N	15 WS	6	69	0	0	0	0	0	0	0	0	6	0	0
#11	04-May	05:07	100	F	0	1	11	0	0	0	0	0	1	0	0	1	1	0
#12a	04-May	05:07	100	F	0	42	327	35	6	2	1	0	9	0	0	42	17	6
#12a	05-May	05:05	100	F	U	37	519	0	11	5	3	2	7	15	2	37	26	3
SKIDEGATE LAKE #1	26-Jul	04:54	95	N	0	1	12	0	0	0	0	0	0	0	0	1	0	0
#2	26-Jul	04:54	100	N	0	0												

Appendix 14. (cont'd)

Station	Date	Sunrise time	Cloud (%)	Precip	Wind (kn)	No. Det.	Keer calls	Alt. Voc.	No. seen	Flightpath			Height			Detections within		
										S	T	C.	A	B	C	500 m	150 m	50 m
YAKOUN LAKE #1	27-Apr	05:21	100	N	0	29	347	7	11	3	0	2	11	3	0	29	25	18
#1	14-May	04:49	5	N	0	10	76	5	0	0	0	0	0	0	0	10	3	0
#1a	27-Jun	04:22	100	R	0	25	323	10	8	5	4	2	7	5	0	25	21	12
#2	09-May	04:58	100	D	0	6	53	0	1	1	0	1	0	1	0	6	4	1
#2	27-Jun	04:22	100	R	0	21	178	2	3	5	2	0	1	10	1	21	14	5
#3	09-May	04:58	100	D	0	11	107	0	0	0	0	3	1	0	0	11	0	0
#4	09-May	04:59	100	D	0	12	201	0	2	1	0	5	0	1	0	12	4	1
#5	10-May	04:56	80	N	5 NE	1	1	0	0	0	0	0	1	0	0	1	0	0
#6	10-May	04:56	90	N	5 NW	0												
#6	29-Jun	04:23	95	D	0	18	296	0	0	0	1	3	5	0	0	10	1	1
#7	10-May	04:56	60	N	5 NE	5	27	0	2	2	0	1	0	5	0	5	3	0
#7	29-Jun	04:23	100	N	0	4	61	0	0	0	1	1	1	1	0	4	2	1
#8	10-May	04:56	90	N	0	0												
#9	30-Jun	04:23	100	N	7 NE	29	657	0	0	0	0	1	0	0	0	8	0	0
#10	30-Jun	04:23	100	N	7 NE	10	151	20	6	0	2	2	7	1	0	10	6	2
#11	01-Jul	04:24	100	N	0	44	519	15	7	10	0	0	5	0	0	10	3	2
#12	01-Jul	04:24	98	N	0	52	858	56	38	1	9	16	17	1	0	44	22	13

a - Precipitation: N=None, F=Fog, R=Rain, U=Unknown

b - Flightpath: S=Straight, T=Turn, C=Circle, U=Unknown

c - Height: A= >10m above treetop, B= <10m above treetop, C=Below treetop, U=Unknown

Appendix 15. Marbled Murrelet activity along road transects through second-growth and old-growth forest habitats in May, June and July, 1990. Habitat at each station is coded: 1 - spruce/hemlock old-growth forest; 2 - cedar/hemlock old-growth forest; 3 - second-growth forest 20-60 years old; and 4 - second-growth forest 60-120 years old. If there was a change in habitat within 500 m of the station (distinguishing only between old-growth and second-growth forest), the type and distance to that different habitat is given.

Station	Date	Type in	Habitat Type near	Habitat Dist (m)	Sunrise (time)	Cloud (%)	Precip[a]	Wind (kn)	Start time	No. Det.	Keer calls	Alt. Voc.	Wings	No. seen	Flightpath[b]			Height[c]			Distance within		
															S	T	C	A	B	C	500 m	150 m	50 m
KAGAN - MISSION																							
9	07-May	4	1	50	05:01	90	N	0	04:25	0													
8	07-May	3	1	100	05:01	90	N	0	04:39	0													
7	07-May	4	2	300	05:01	90	N	0	04:58	1	2			0	0	0	0	0	0	0	1	0	0
6	07-May	3	1	400	05:01	90	N	0	05:16	0													
5	07-May	3	1	500	05:01	90	N	0	05:28	0													
4	07-May	3			05:01	90	N	0	05:42	0													
3	07-May	3			05:01	90	N	0	05:55	0													
2	07-May	4			05:01	90	N	0	06:09	0													
YAKOUN 3 - 10 km																							
3	07-May	4			05:01	100	N	5 S	04:16	0													
4	07-May	4			05:01	100	N	5 S	04:28	0													
5	07-May	4			05:01	100	D	5 S	04:40	0													
6	07-May	4			05:01	100	D	5 S	04:52	0													
7	07-May	4	1	50	05:01	100	N	5 S	05:04	1	3			0	0	0	0	0	0	0	1	0	0
8	07-May	4	2	20	05:01	100	N	5 S	05:16	0													
9	07-May	4	2	20	05:01	100	N	5 S	05:28	2	0			1	1	1	0	2	0	0	2	2	1
10	07-May	4	2	50	05:01	50	N	5 S	05:40	0													
YAKOUN 11 - 20 km																							
11	07-May	4	2	50	05:01	90	N	15 NW	04:16	0													
12	07-May	4	2	200	05:01	90	N	15 NW	04:28	0													
13	07-May	4	2	100	05:01	90	N	15 NW	04:40	0													
14	07-May	4	2	50	05:01	90	N	15 NW	04:54	0													
15	07-May	4			05:01	90	N	15 NW	05:07	0													
16	07-May	4			05:01	90	N	15 NW	05:19	0													
17	07-May	4			05:01	90	N	15 NW	05:32	0													
18	07-May	4			05:01	90	N	15 NW	05:45	0													
19	07-May	4			05:01	90	N	15 NW	05:58	0													
20	07-May	4			05:01	90	N	15 NW	06:11	0													
YAKOUN 21 - 30 km																							
21	08-May	4			04:59	25	N	0	04:14	0													
22	08-May	4			04:59	50	N	0	04:28	0													
23	08-May	2	4	300	04:59	60	N	0	04:41	3	34			1	0	1	0	1	0	0	3	1	1
24	08-May	4	2	200	04:59	75	N	0	04:54	1	25			0	0	0	0	0	0	0	1	0	0
25	08-May	4	2	400	04:59	50	N	0	05:07	0													
26	08-May	4	2	500	04:59	50	N	0	05:20	0													
27	08-May	4	2	400	04:59	50	N	0	05:33	0													
28	08-May	4	2	150	04:59	60	N	0	05:47	0													
29	08-May	4	2	100	04:59	50	N	0	05:59	0													
30	08-May	4	2	400	04:59	50	N	0	06:11	0													

Appendix 15 (cont'd)

Station	Date	Type in	Habitat		Sunrise (time)	Cloud (%)	Precip[a]	Wind (kn)	Start time	No. Det.	Keer calls	Alt. Voc.	Wings	No. seen	Flightpath[b]			Height[c]			Distance within		
			Type near	Dist (m)											S	T	C	A	B	C	500 m	150 m	50 m
PHANTOM CREEK																							
1	08-May	4	2	20	05:00	50	N	15 NW	04:15	1	2			0	0	0	0	0	1	0	1	1	1
2	08-May	1			05:00	90	N	15 NW	04:28	4	83	4		0	0	0	1	4	0	0	4	2	1
3	08-May	1			05:00	100	N	15 NW	04:40	5	103	3		0	0	0	2	1	2	0	5	5	0
4	08-May	2			05:00	100	N	15 NW		Missed due to flat tire													
5	08-May	2			05:00	100	N	15 NW	05:05	1	4			0	1	0	0	0	0	0	1	0	0
6	08-May	1	4	300	05:00	100	N	15 NW	05:17	0													
7	08-May	4			05:00	100	N	15 NW	05:30	0													
8	08-May	4			05:00	100	N	15 NW	05:43	0													
RENNELL SOUND #2																							
1	08-May	1	4	50	05:00	90	N	15 NW	04:15	1	0			1	0	0	0	0	1	0	1	1	1
2	08-May	4			05:00	90	N	15 NW	04:29	1	15			0	1	0	0	0	0	0	1	0	0
3	08-May	4			05:00	90	N	15 NW	04:47	0													
4	08-May	2	4	200	05:00	90	N	15 NW	05:01	0													
5	08-May	4	2	300	05:00	90	N	15 NW	05:16	2	38			0	2	0	0	2	0	0	2	2	1
6	08-May	4	2	300	05:00	90	N	15 NW	05:31	0													
7	08-May	4	2	300	05:00	90	N	15 NW	05:45	0													
8	08-May	2	4	200	05:00	90	N	15 NW	05:59	0													
KAGAN - MISSION																							
9	09-Jun	4	1	50	04:21	30	N	10 NE	03:06	0													
8	09-Jun	3	1	100	04:21	30	N	10 NE	03:20	0													
7	09-Jun	4	2	300	04:21	30	N	10 NE	03:35	1	9			0	1	0	0	0	0	0	1	1	0
6	09-Jun	3	1	400	04:21	30	N	10 NE	03:49	0													
5	09-Jun	3	1	500	04:21	30	N	10 NE	04:04	0													
4	09-Jun	3			04:21	30	N	10 NE	04:18	0													
3	09-Jun	3			04:21	10	N	10 NE	04:31	0													
2	09-Jun	4			04:21	10	N	10 NE	04:45	0													
YAKOUN	3 - 10 km																						
3	07-Jun	4			04:22	5	N	0	03:08	0													
4	07-Jun	4			04:22	5	N	0	03:22	0													
5	07-Jun	4			04:22	5	N	0	03:34	0													
6	07-Jun	4			04:22	5	N	0	03:46	0													
7	07-Jun	4	1	50	04:22	5	N	0	03:58	4	124	5		0	3	0	0	1	0	0	4	1	1
8	07-Jun	4	2	20	04:22	5	N	0	04:12	0													
9	07-Jun	4	2	20	04:22	5	N	0	04:25	0													
10	07-Jun	4	2	50	04:22	5	N	0	04:37	0													
YAKOUN	11 - 20 km																						
11	06-Jun	4	2	50	04:22	5	N	U	03:11	0													
12	06-Jun	4	2	200	04:22	5	N	U	03:24	0													
13	06-Jun	4	2	100	04:22	5	N	U	03:36	0													
14	06-Jun	4	2	50	04:22	5	N	U	03:48	0													
15	06-Jun	4			04:22	5	N	U	04:01	0													
16	06-Jun	4			04:22	5	N	U	04:13	0													

Appendix 15. (cont'd)

Station	Date	Type in	Habitat Type near	Habitat Dist (m)	Sunrise (time)	Cloud (%)	Precip[a]	Wind (kn)	Start time	No. Det.	Keer calls	Alt. Voc.	Wings	No. seen	Flightpath[b] S	Flightpath[b] T	Flightpath[b] C	Height[c] A	Height[c] B	Height[c] C	Distance within 500 m	Distance within 150 m	Distance within 50 m
17	06-Jun	4			04:22	5	N	U	04:25	0													
18	06-Jun	4			04:22	5	N	U	04:38	0													
19	06-Jun	4			04:22	5	N	U	04:50	0													
20	06-Jun	4			04:22	5	N	U	05:02	0													
YAKOUN 21 - 30 km																							
21	09-Jun	4			04:21	60	N	0	03:06	0													
22	09-Jun	4			04:21	60	N	0	03:18	0													
23	09-Jun	2	4	300	04:21	60	N	0	03:20	0													
24	09-Jun	4	2	200	04:21	60	N	0	03:42	1	4	5		0	0	0	0	1	0	0	1	1	1
25	09-Jun	4	2	400	04:21	60	N	0	03:55	0													
26	09-Jun	4	2	500	04:21	60	N	0	04:07	1	7	5		0	0	0	0	0	0	0	1	0	0
27	09-Jun	4	2	400	04:21	60	N	0	04:19	0													
28	09-Jun	4	2	150	04:21	60	N	0	04:31	2	32			0	0	0	0	0	0	0	2	0	0
29	09-Jun	4	2	100	04:21	60	N	0	04:43	1	8			0	0	0	0	0	0	0	1	0	0
30	09-Jun	4	2	400	04:21	60	N	0	04:57	0													
PHANTOM CREEK																							
1	09-Jun	4	2	20	04:21	10	N	0	03:06	0													
2	09-Jun	1			04:21	10	N	0	03:19	3	21	4		0	1	0	0	0	1	0	3	3	2
3	09-Jun	1			04:21	50	N	0	03:32	4	61	3	1	0	1	0	0	0	1	0	4	1	1
4	09-Jun	2			04:21	50	N	0	03:45	0													
5	09-Jun	2			04:21	50	N	0	03:58	11	141			3	2	1	1	3	0	0	11	5	2
6	09-Jun	1	4	300	04:21	50	N	0	04:14	2	29			0	0	0	0	0	0	0	2	0	0
7	09-Jun	4			04:21	50	N	0	04:27	0													
8	09-Jun	4			04:21	50	N	0	04:40	0													
RENNELL SOUND #2																							
1	09-Jun	1	4	50	04:21	0	N	0	03:12	1	10			0	1	0	0	0	0	0	1	1	1
2	09-Jun	4			04:21	0	N	0	03:28	0													
3	09-Jun	4			04:21	0	N	0	03:42	0													
4	09-Jun	2	4	200	04:21	0	N	0	03:57	2	29		1	2	0	0	1	0	0	1	2	2	1
5	09-Jun	4	2	300	04:21	0	N	0	04:14	0													
6	09-Jun	4	2	300	04:21	0	N	0	04:27	0													
7	09-Jun	4	2	300	04:21	0	N	0	04:40	0													
8	09-Jun	2	4	200	04:21	0	N	0	04:54	0													
YAKOUN 3 - 10 km																							
3	09-Jul	4			04:32	1	N	U	03:32	0													
4	09-Jul	4			04:32	1	N	U	03:45	0													
5	09-Jul	4			04:32	1	N	U	04:05	0													
6	09-Jul	4			04:32	1	N	U	04:20	0													
7	09-Jul	4	1	50	04:32	1	N	U	04:32	0													
8	09-Jul	4	2	20	04:32	1	N	U	04:49	2	9			0	0	0	0	2	0	0	0	0	0
9	09-Jul	4	2	20	04:32	1	N	U	04:58	0													
10	09-Jul	4	2	50	04:32	1	N	U	05:10	0													

Appendix 15. (cont'd)

Station	Date	Habitat Type in	Habitat Type near	Habitat Dist (m)	Sunrise (time)	Cloud (%)	Precip[a]	Wind (kn)	Start time	No. Det.	Keer calls	Alt. Voc.	Wings	No. seen	Flightpath[b] S	Flightpath[b] T	Flightpath[b] C	Height[c] A	Height[c] B	Height[c] C	Distance within 500 m	Distance within 150 m	Distance within 50 m
YAKOUN 11 - 20 km																							
11	10-Jul	4	2	50	04:33	100	R	5	03:33	1	4			0	0	0	0	0	0	0	1	1	0
12	10-Jul	4	2	200	04:33	100	R	5	03:49	0													
13	10-Jul	4	2	100	04:33	100	R	5	04:02	0													
14	10-Jul	4	2	50	04:33	100	R	5	04:15	0													
15	10-Jul	4			04:33	100	R	5	04:27	0													
16	10-Jul	4			04:33	100	R	5	04:41	0													
17	10-Jul	4			04:33	100	R	5	04:54	0													
18	10-Jul	4			04:33	100	R	5	05:07	0													
19	10-Jul	4			04:33	50	N	5	05:19	0													
20	10-Jul	4			04:33	50	N	5	05:32	0													
YAKOUN 21 - 30 km																							
21	11-Jul	4			04:34	100	N	3	03:34	1	2			0	0	0	0	1	0	0	0	0	0
22	11-Jul	4			04:34	100	N	3	03:47	0													
23	11-Jul	2	4	300	04:34	100	N	3	03:59	0													
24	11-Jul	4	2	200	04:34	100	N	3	04:12	0													
25	11-Jul	4	2	400	04:34	100	N	3	04:27	0													
26	11-Jul	4	2	500	04:34	100	N	3	04:40	0													
27	11-Jul	4	2	400	04:34	100	N	3	04:52	5	61	0		3	0	0	1	5	0	0	3	1	1
28	11-Jul	4	2	150	04:34	100	N	3	05:20	0													
29	11-Jul	4	2	100	04:34	100	N	3	05:35	0													
30	11-Jul	4	2	400	04:34	100	N	3	05:48	0													
PHANTOM CREEK																							
1	14-Jul	4	2	20	04:37	90	N	U	03:37	1	2			0	0	0	0	0	1	0	1	1	1
2	14-Jul	1			04:37	90	N	U	03:50	8	38			0	0	0	0	0	7	0	1	1	1
3	14-Jul	1			04:37	90	N	U	04:04	5	9			2	0	0	0	0	2	0	0	0	0
4	14-Jul	2			04:37	90	N	U	04:18	9	58			1	0	0	0	0	0	0	0	0	0
5	14-Jul	2			04:37	90	N	U	04:31	10	104			23	0	0	0	0	0	5	1	0	0
6	14-Jul	1	4	300	04:37	90	N	U	04:44	7	34			13	0	0	0	1	0	2	0	0	0
7	14-Jul	4			04:37	90	N	U	04:58	9	93			10	0	0	0	3	0	0	4	0	0
8	14-Jul	4			04:37	90	N	U	05:11	3	3			0	0	0	0	1	0	0	0	0	0
RENNEL SOUND #2																							
1	15-Jul	1	4	50	04:39	80	N	12 NW	03:39	3	22			0	1	0	0	0	0	0	0	0	0
2	15-Jul	4			04:39	80	N	12 NW	03:52	0													
3	15-Jul	4			04:39	80	N	12 NW	04:06	0													
4	15-Jul	2	4	200	04:39	80	N	12 NW	04:20	3	5			3	0	0	1	0	0	0	1	1	1
5	15-Jul	4	2	300	04:39	80	N	12 NW	04:33	3	14			5	0	0	1	0	0	0	0	0	0
6	15-Jul	4	2	300	04:39	80	N	12 NW	04:46	4	56			0	0	0	0	0	0	0	0	0	0
7	15-Jul	4	2	300	04:39	80	N	12 NW	04:59	2	11			0	0	0	0	0	0	0	0	0	0
8	15-Jul	2	4	200	04:39	80	N	12 NW	05:12	1	2			0	0	0	0	0	0	0	0	0	0

a - Precipitation: N=None, F=Fog, R=Rain, U=Unknown
b - Flightpath: S=Straight, T=Turn, C=Circle, U=Unknown
c - Height: A= >10m above treetop, B= <10m above treetop, C=Below treetop, U=Unknown

Appendix 16[1]

Marbled Murrelet habitat use near lakes in the Queen Charlotte Islands.

T.E. Reimchen
Adjunct Professor
Department of Biology
University of Victoria
Victoria, B.C.

Permanent Field Address
Box 970
Queen Charlotte City, B.C.
559-8648

---

1 - When quoting or referring to data contained in this appendix, use the following reference:

Reimchen, T.E. 1991. Marbled Murrelet habitat use in the Queen Charlotte Islands. Pp.101-107 In M.S. Rodway, J-P.L. Savard and H.M. Regehr. Habitat use and activity patterns of Marbled Murrelets at Inland and at-sea sites in the Queen Charlotte Islands, British Columbia. Techical Report Series No. 122, Can. Wildl. Serv. Pacific and Yukon Region, British Columbia.

Appendix 16 (cont'd)

Background

During geographical surveys to most lakes on the Queen Charlotte Islands over the last 12 years, I made general notes on the biota within and around the lake basins. I have extracted from these field diaries all records pertaining to Marbled Murrelet (MAMU) flight activity and present here a compilation of these data. In 1986, I sent a student to Coates Lake on the west side of Graham Island where I had observed extensive MAMU flight activity. I had him maintain vocal and flight records of MAMU from May 15 to August 5. This work, (Eisenhawer and Reimchen 1990) describes extensive tree use by MAMU over the summer, shows high fidelity of flight paths on successive nights, develops a methodology of monitoring habitat use and suggests methods of locating potential nesting trees.

Among the 225 lakes present in the original surveys, I have excluded 176 because they were visited outside of the optimal time periods (May 25-July 25) or did not include observations during dawn twilight. This leaves 49 lakes with useful data. General geographical distribution of MAMU activity observed in these surveys is shown in Figure 1, while regional distributions are given in Figures 2-6. MAMU were absent or rare (no more than 2 calls per 15 minute interval) at forty lakes and most of these occurred in non-forested or poorly forested terrain on Moresby and

Graham islands. Nine lakes had extensive vocal and flight activity (up to 60 calls per 15 minutes) and these are distributed primarily in old-growth forests on western regions of the Charlottes.

Northeast Graham (Figure 2)

Most ponds and lakes in this region were visited, yet MAMU were rarely observed. Extensive year round bird inventories over a five year period at one of the representative lakes (Reimchen and Douglas 1984, Can. Field-Nat.) confirms a paucity of MAMU activity. It was with some surprise that at a small lake in the middle of the Sphagnum dominated habitat, we encountered extensive MAMU activity from adjacent cedar/hemlock forests with up to seven birds circling the pond at a single time. Trees were short (10-30 m) but occasionally moss-laden. During the following night, we were at a larger lake (South Otter), 6 km to the northwest, which was surrounded by extensive moss-laden forests. Yet we heard and observed no MAMU at this lake during the evening and subsequent morning. This indicates that in this region of northeast Graham Island, MAMU habitat can be highly localized. The single locality, which is surrounded by apparently similar but unused habitat, may be a useful area for identifying optimal MAMU requirements.

Appendix 16 (cont'd)

West-central Graham (Figure 3)

The greatest MAMU activity that I observed anywhere in the Charlottes occurred at two small lakes (Upper and Lower Rainbow) at the headwaters of Coates River. During our overnight visit (June 23-24, 1982) to Lower Rainbow, there was virtually uninterrupted vocal and flight activity from 0445 to 0545 generally within 50 m of us. The forest surrounding these lakes is composed of widely spaced and tall spruce which were heavily moss laden. Within several minutes of initial observation, we first heard and then saw a MAMU leave a tree adjacent to us. We walked several hundred meters up the slope and observed additional flights at close range as the birds flew down towards the lake where they circled for several minutes before leaving for marine waters. Although this lake is too small for a float plane, a helicopter equipped with pontoons could give ready access. Additional observations may be fruitful. The adjacent lake (Coates), which is much larger than the Rainbow Lakes also had extensive flight activity by MAMU but this was not as concentrated as at the Rainbow Lakes. We suspected that most of the flight activity to and from the forests involves breeding birds. However, some of the MAMU used different trees on successive nights and these may be non-breeders.

Appendix 16 (cont'd)

South Graham (Figure 4)

Of 11 lakes surveyed, MAMU activity was extensive only at Seal Inlet Lake where birds were commonly seen flying up to surrounding ridges in the evening. This has the largest stands of old-growth of the lakes surveyed on South Graham.

North Moresby (Figure 5)

Two localities (Kaisun and Moresby Lake) had extensive flight activity but there were no obvious focal areas in adjacent forests where birds were seen at higher frequencies.

South Moresby (Figure 6)

MAMU were uncommon in the majority of lakes visited in this region and most shores on these lakes were not heavily forested. Greatest activity was observed in old-growth forests of Tasu Sound where MAMU were frequently observed flying into the higher elevation ridges.

Recommendations

A survey of MAMU at selected lakes throughout the Charlottes should be undertaken. Lakes are ideal for such studies because the immediate airspace above the lake surface is extensively used by MAMU for circular flights and vocals prior to entry and departure from the canopy and these can be easily documented. Among the 225

Appendix 16 (cont'd)

lakes in the Charlottes that I have sampled during the studies of resident fish and avian piscivores, I have chosen 29 (Figs. 7-11) that if surveyed for MAMU, would quantify the geographical distribution and habitat preferences of MAMU on the Charlottes. This would produce a framework from which reasonable policies could be developed and direction for additional research be determined.

The surveys could be done efficiently with four teams each with two observers. A team would camp for up to five days, allowing replicate observations at dawn twilight. Circular flight activity and corresponding vocals would be recorded. In our 1986 study, we have used number of calls throughout the twilight period as a description of MAMU activity. Several factors contributed to variance in daily call frequency. The most important was weather conditions, with call rates increasing during misty or foggy mornings and decreasing during very calm, clear conditions and possibly decreasing during storm activity although the latter may be due to reduced detection. There was also considerable unexplained variance in flight calls on consecutive mornings with comparable viewing conditions. Observations over a five day period would improve the confidence in establishing the extent of habitat use at each lake and would allow statistical calibration of call frequencies among lakes in relation to viewing conditions. To allow comparisons among lakes, the field season should be restricted to June and July. At Coates Lake, where detailed observations of MAMU were made in spring and summer, call

Appendix 16 (cont'd)

frequencies were not a reliable index in May and late July when there appeared to be frequent flight activity but fewer vocalizations than in June and early August.

Trees showing repeated nightly use by MAMU should be permanently marked for future reference (metal tags). The fidelity of flight paths and flight times by individual birds on successive nights can be exploited to locate destination trees. Climbing of these may be possible in some cases although in my experience at Coates Lake, none of the 12 destination trees located could be climbed without supplemental gear. Light weight aluminum ladders which clamp to the trunk would allow a novice to gain access to the canopy without much difficulty.

Habitat characteristics fundamental to MAMU activity are not known with any confidence and considerable attention must be given to defining a variable set that can be readily quantified by each team. The major problem with different teams is comparability of observational data. Presumably, a useful variable set can only be developed after systematic data on MAMU abundance is obtained at different lakes. Slope, wind protection, distance between trees, tree height relative to surrounding trees, moss cover in canopy and moss cover on the ground appear to be associated with MAMU habitat use.

At this stage in the MAMU investigation, it is imperative that the macrogeographical distribution of MAMU be documented. The survey of lakes could be completed in two summer seasons and some

Appendix 16 (cont'd)

general forestry policies formulated. Results of this would allow areas of high use to be identified and this will certainly help to focus subsequent stages of the program where more detailed observations could be undertaken.

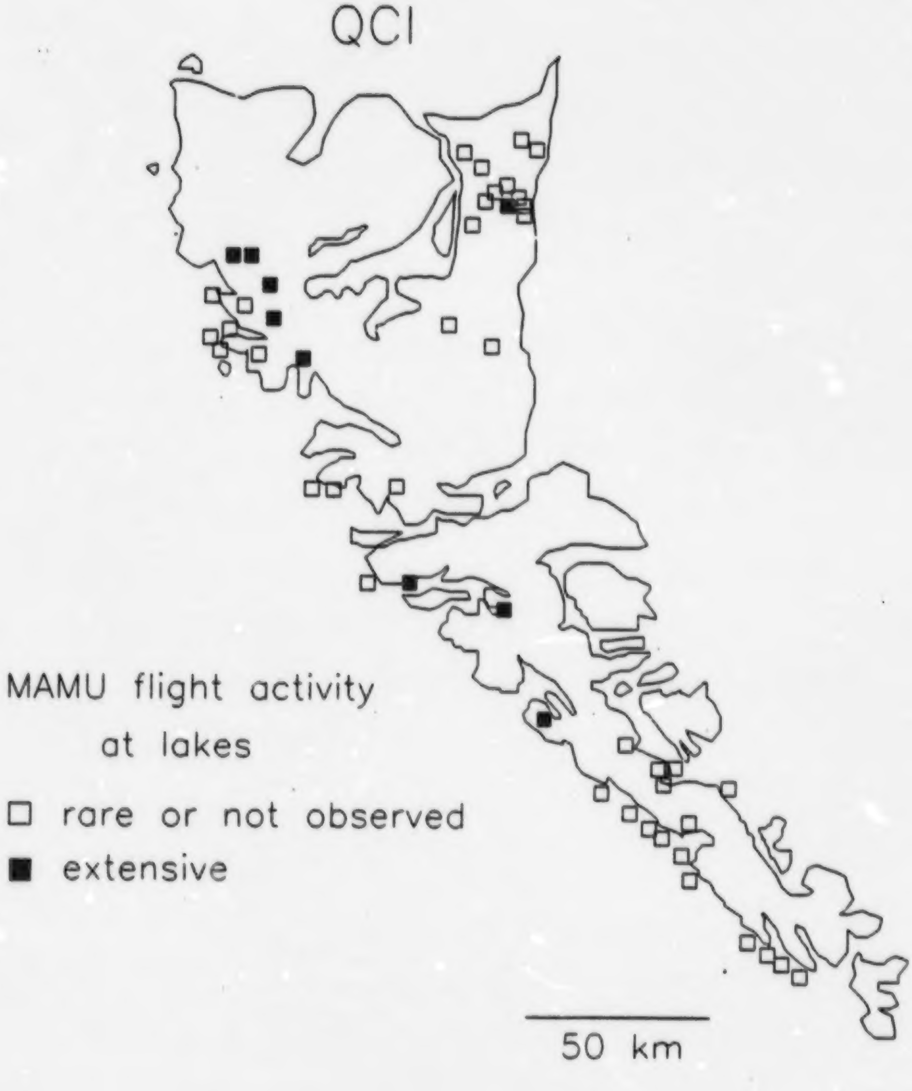


Fig. 1. General distribution of Marbled Murrelet flight activity observed at dawn twilight at lakes on the Queen Charlotte Islands. Observation period -May 25 to July 25. Classification of call activity: rare-maximum of two calls per 15 minute interval; extensive - up to 60 calls per 15 minute. Data extracted from field surveys (1977-1986).

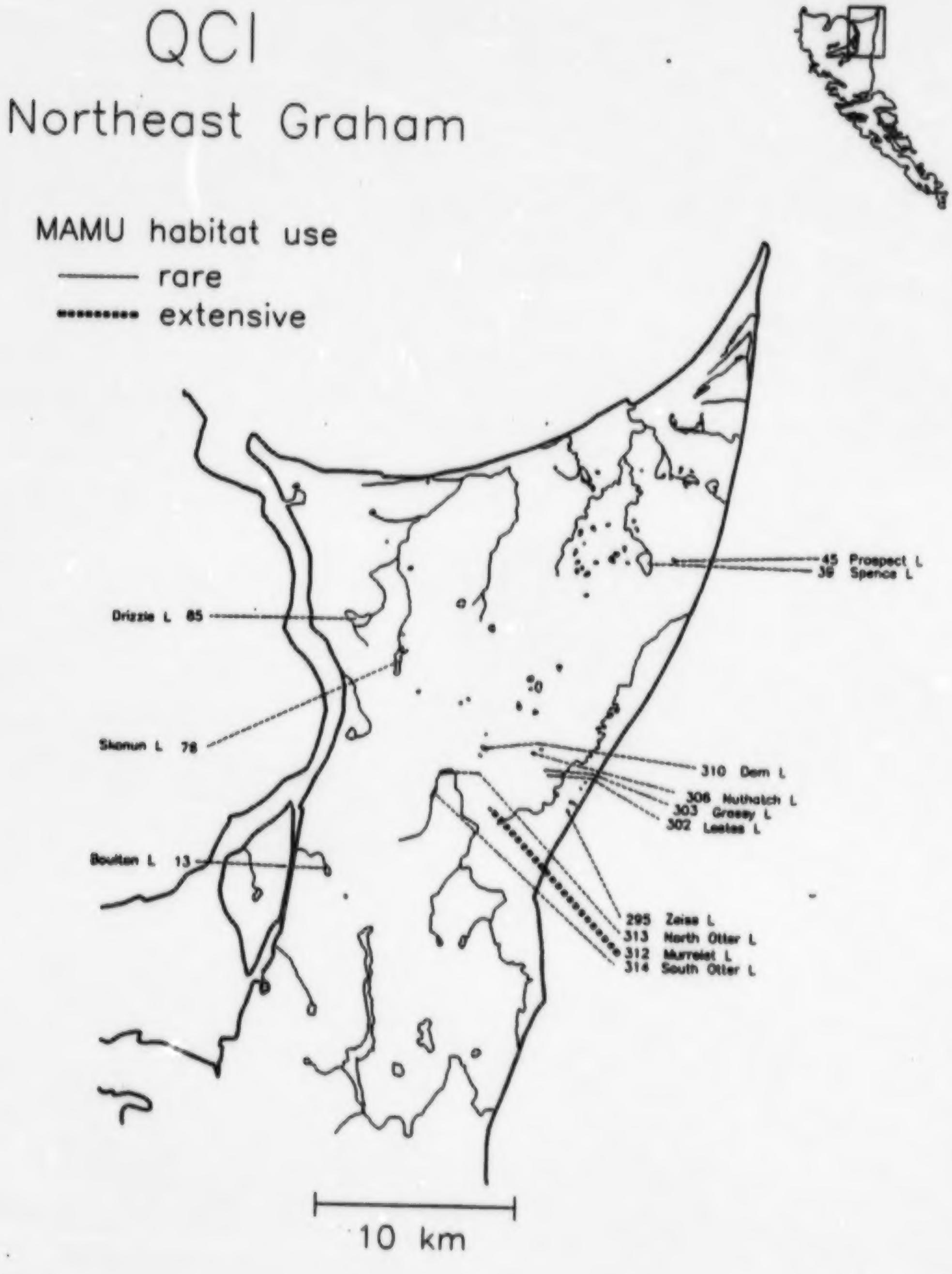

QCI
Northeast Graham
MAMU habitat use
rare
extensive
45 Prospect L
39 Spence L
Drizzle L 85
Skonun L 78
310 Dam L
308 Nuthatch L
303 Grassy L
302 Leeles L
Boulton L 13
295 Zeiss L
313 North Otter L
312 Murrelet L
314 South Otter L
10 km

Figure 2.

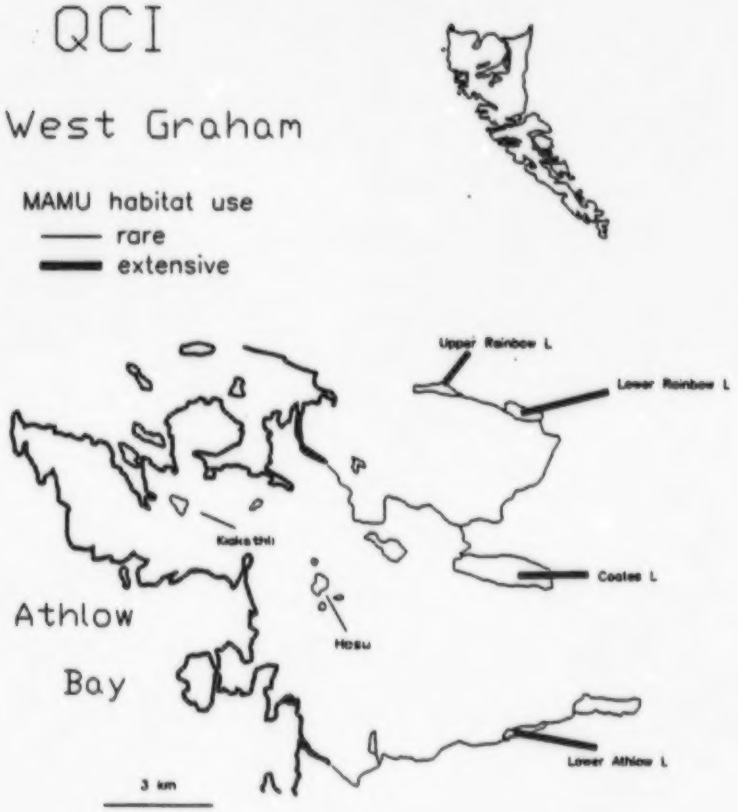

QCI
West Graham
MAMU habitat use
rare
extensive
Upper Rainbow L
Lower Rainbow L
Kiokathli
Coates L
Athlow
Bay
Hosu
Lower Athlow L
3 km

Figure 3.

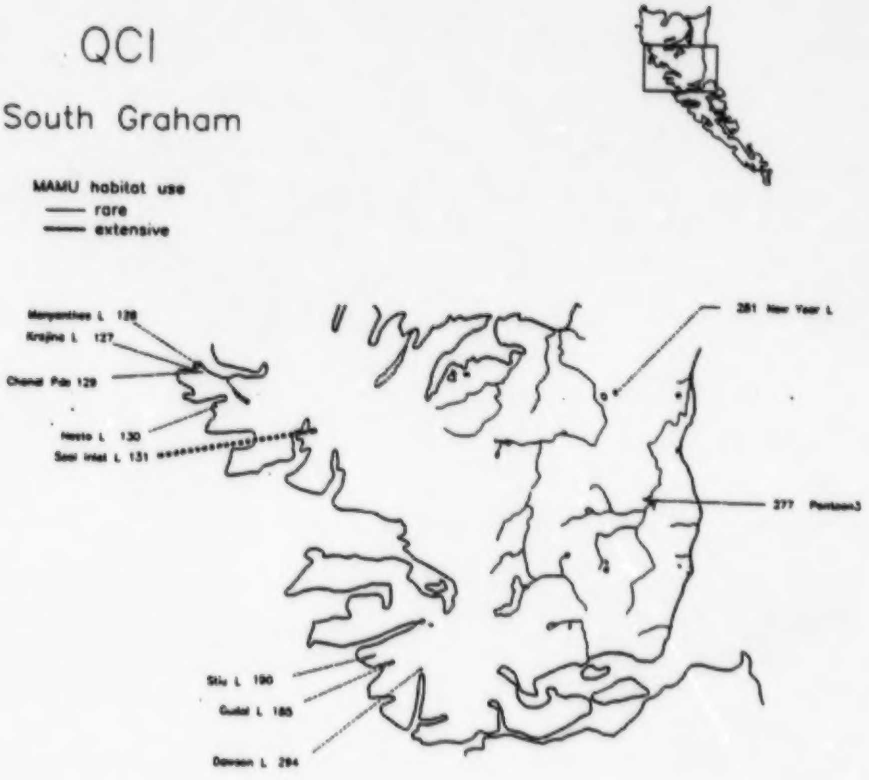

QCI
South Graham
MAMU habitat use
rare
extensive
Menyanthes L 128
Krajina L 127
Chanal Pds 129
Nesto L 130
Seal Inlet L 131
281 New Year L
277 Pontoon3
Stiu L 190
Gudal L 185
Dawson L 284

Figure 4.

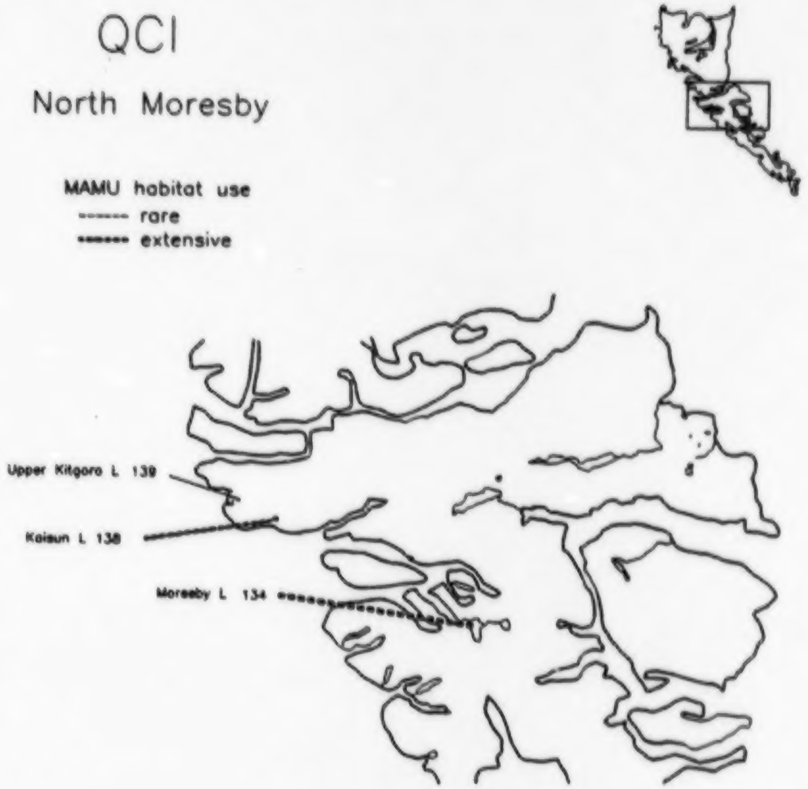

QCI
North Moresby
MAMU habitat use
------ rare
====== extensive
Upper Kitgoro L 139
Kaisun L 138
Moresby L 134

Figure 5.

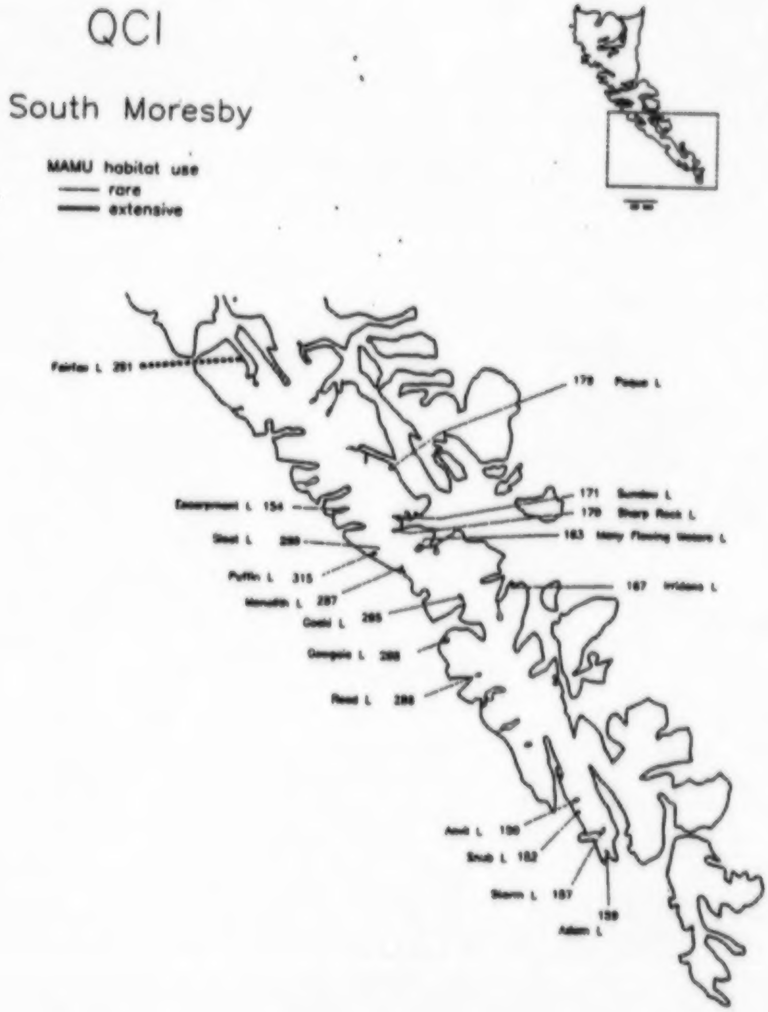

QCI
South Moresby
MAMU habitat use
rare
extensive
Fairfax L. 281
178 Pogue L.
171 Sundew L.
179 Sharp Rock L.
183 Many Flowing Waters L.
Escarpment L. 154
Steel L. 289
Puffin L. 315
Meredith L. 287
Coste L. 285
187 Hidden L.
Gowgaia L. 288
Reed L. 288
Auk L. 190
Snub L. 192
Storm L. 197
199
Adam L.

Figure 6.

Figures 7-11. Geographical survey of lakes on the Queen Charlotte Islands at which habitat data was obtained. Lakes recommended for MAMU study are shown in bold.

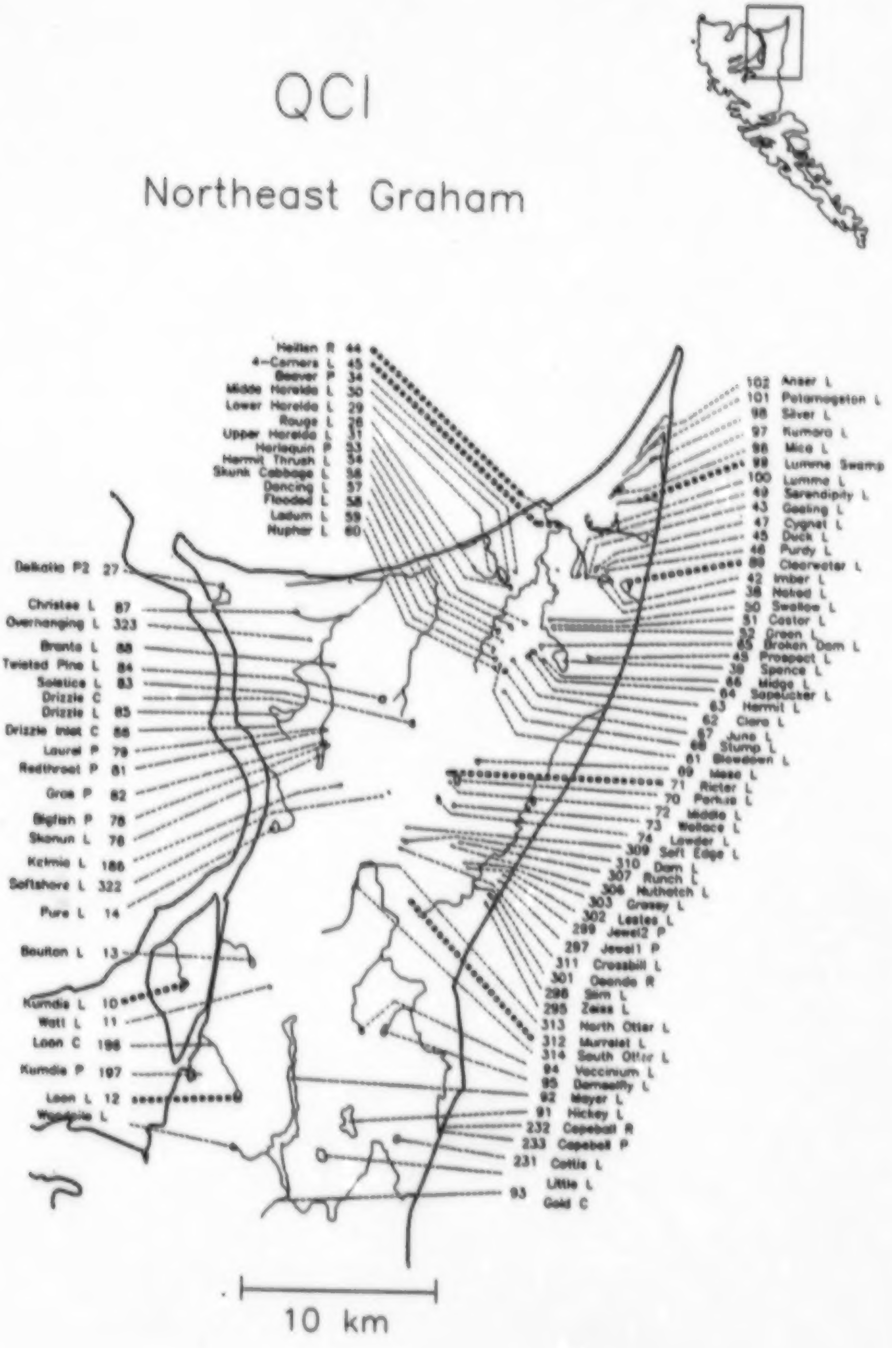

QCI
Northeast Graham
Hellen R 44
4-Corners L 45
Beaver P 34
Middle Horelda L 30
Lower Horelda L 29
Rouge L 28
Upper Horelda L 31
Harlequin P 33
Hermit Thrush L 54
Skunk Cabbage L 56
Dancing L 57
Flooded L 58
Ladum L 59
Nuphar L 60
Delkatla P2 27
Christes L 87
Overhanging L 323
Branta L 88
Twisted Pine L 84
Solstice L 83
Drizzle C
Drizzle L 85
Drizzle Inlet C 86
Laurel P 79
Redthroat P 81
Gros P 82
Bigfish P 78
Skonun L 76
Kalmia L 186
Softshore L 322
Pure L 14
Boulton L 13
Kumdis L 10
Watt L 11
Loon C 196
Kumdis P 197
Loon L 12
Woodpile L
102 Anser L
101 Potamogeton L
98 Silver L
97 Kumara L
96 Mica L
99 Lumme Swamp
100 Lumme L
49 Serendipity L
43 Gosling L
47 Cygnet L
45 Duck L
46 Purdy L
89 Clearwater L
42 Imber L
38 Naked L
50 Swallow L
51 Castor L
52 Green L
65 Broken Dam L
48 Prospect L
39 Spence L
66 Midge L
64 Sapsucker L
63 Hermit L
62 Clara L
67 Juno L
68 Stump L
61 Blowdown L
69 Mesa L
71 Rictor L
70 Perkus L
72 Middle L
73 Wallace L
74 Lowder L
309 Soft Edge L
310 Dam L
307 Runch L
306 Nuthatch L
303 Grassy L
302 Lestes L
299 Jewel2 P
297 Jewel1 P
311 Crossbill L
301 Oeonda R
298 Slim L
295 Zeiss L
313 North Otter L
312 Murrelet L
314 South Otter L
94 Vaccinium L
95 Damselfly L
92 Mayer L
91 Hickey L
232 Capeball R
233 Capeball P
231 Cattle L
Little L
93 Gold C
10 km

Figure 7.

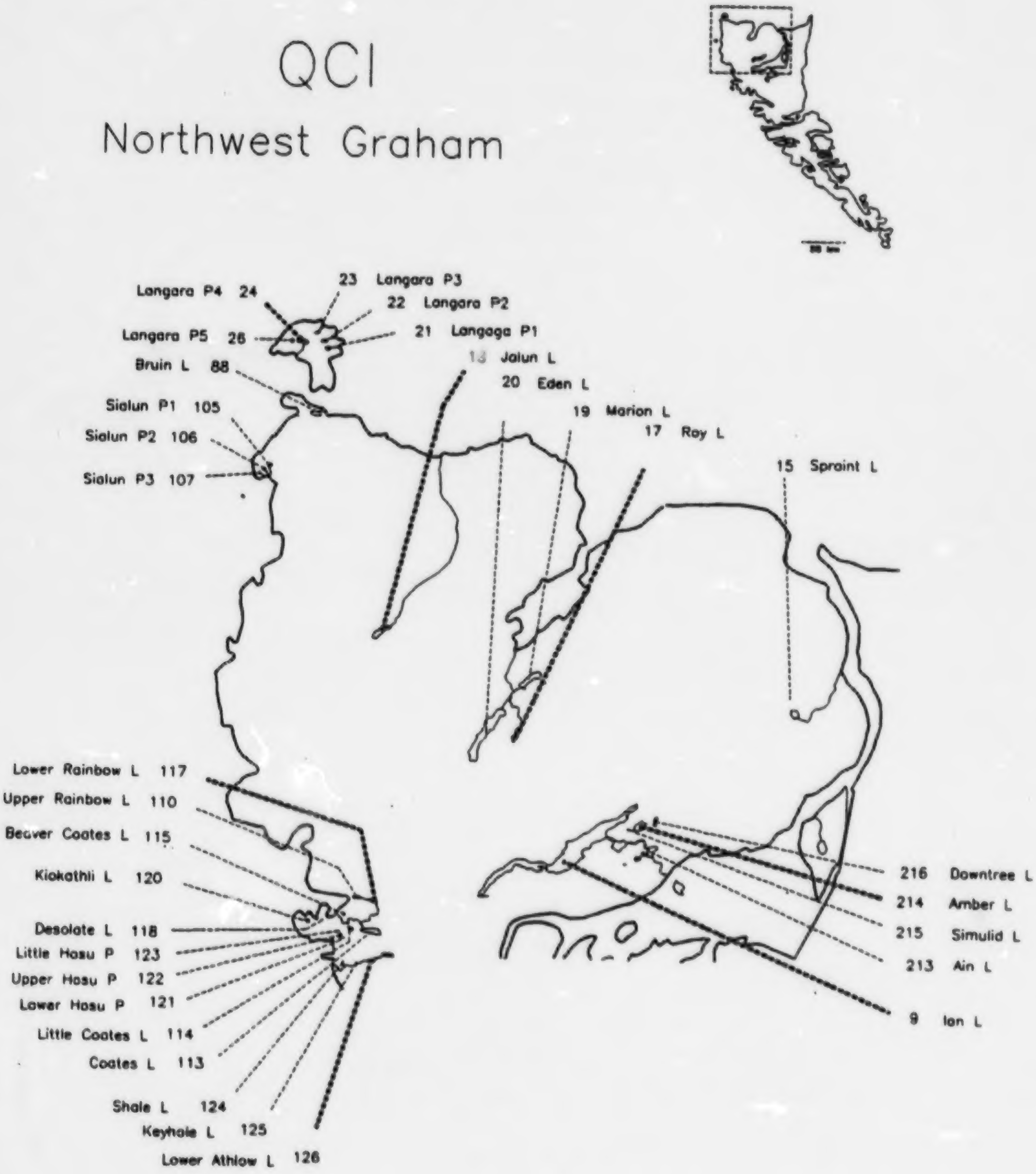

QCI
Northwest Graham
Langara P4 24
23 Langara P3
22 Langara P2
21 Langaga P1
Langara P5 26
13 Jalun L
20 Eden L
Bruin L 88
19 Marion L
17 Ray L
Sialun P1 105
Sialun P2 106
Sialun P3 107
15 Spraint L
Lower Rainbow L 117
Upper Rainbow L 110
Beaver Coates L 115
Kiokathli L 120
Desolate L 118
Little Hosu P 123
Upper Hosu P 122
Lower Hosu P 121
Little Coates L 114
Coates L 113
Shale L 124
Keyhole L 125
Lower Athlow L 126
216 Downtree L
214 Amber L
215 Simulid L
213 Ain L
9 Ian L

Figure 8.

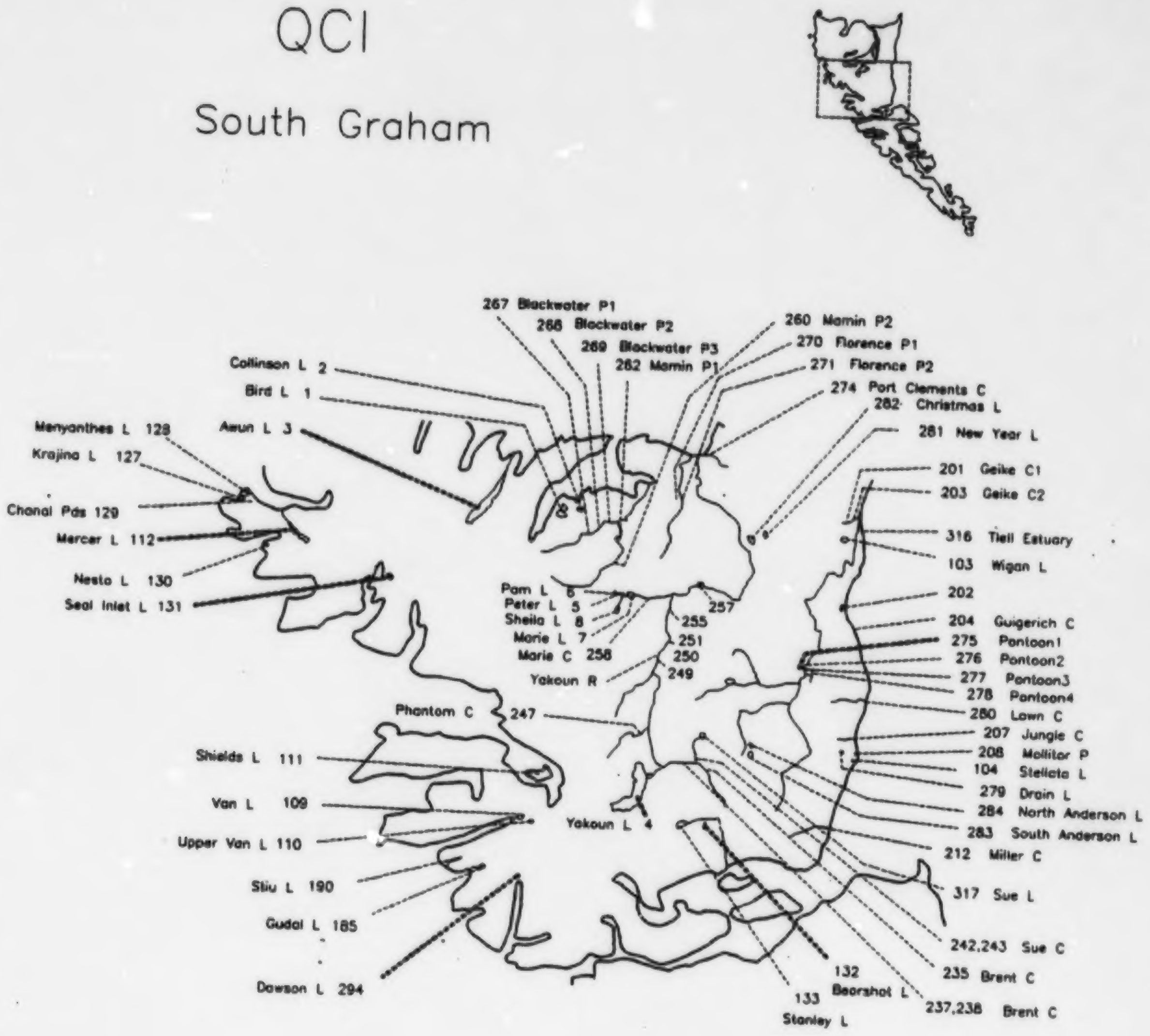

QCI
South Graham
267 Blackwater P1
268 Blackwater P2
269 Blackwater P3
262 Mamin P1
260 Mamin P2
270 Florence P1
271 Florence P2
274 Port Clements C
282 Christmas L
281 New Year L
201 Geike C1
203 Geike C2
316 Tlell Estuary
103 Wigan L
202
204 Guigerich C
275 Pontoon1
276 Pontoon2
277 Pontoon3
278 Pontoon4
280 Lawn C
207 Jungle C
208 Mollitor P
104 Stellata L
279 Drain L
284 North Anderson L
283 South Anderson L
212 Miller C
317 Sue L
242,243 Sue C
235 Brent C
237,238 Brent C
132 Bearshot L
133 Stanley L
Collinson L 2
Bird L 1
Awun L 3
Menyanthes L 128
Krajina L 127
Chanal Pds 129
Mercer L 112
Nesto L 130
Seal Inlet L 131
Pam L 6
Peter L 5
Sheila L 8
Marie L 7
Marie C 258
Yakoun R
257
255
251
250
249
Phantom C
247
Shields L 111
Van L 109
Upper Van L 110
Yakoun L 4
Sliu L 190
Gudal L 185
Dawson L 294

Figure 9.

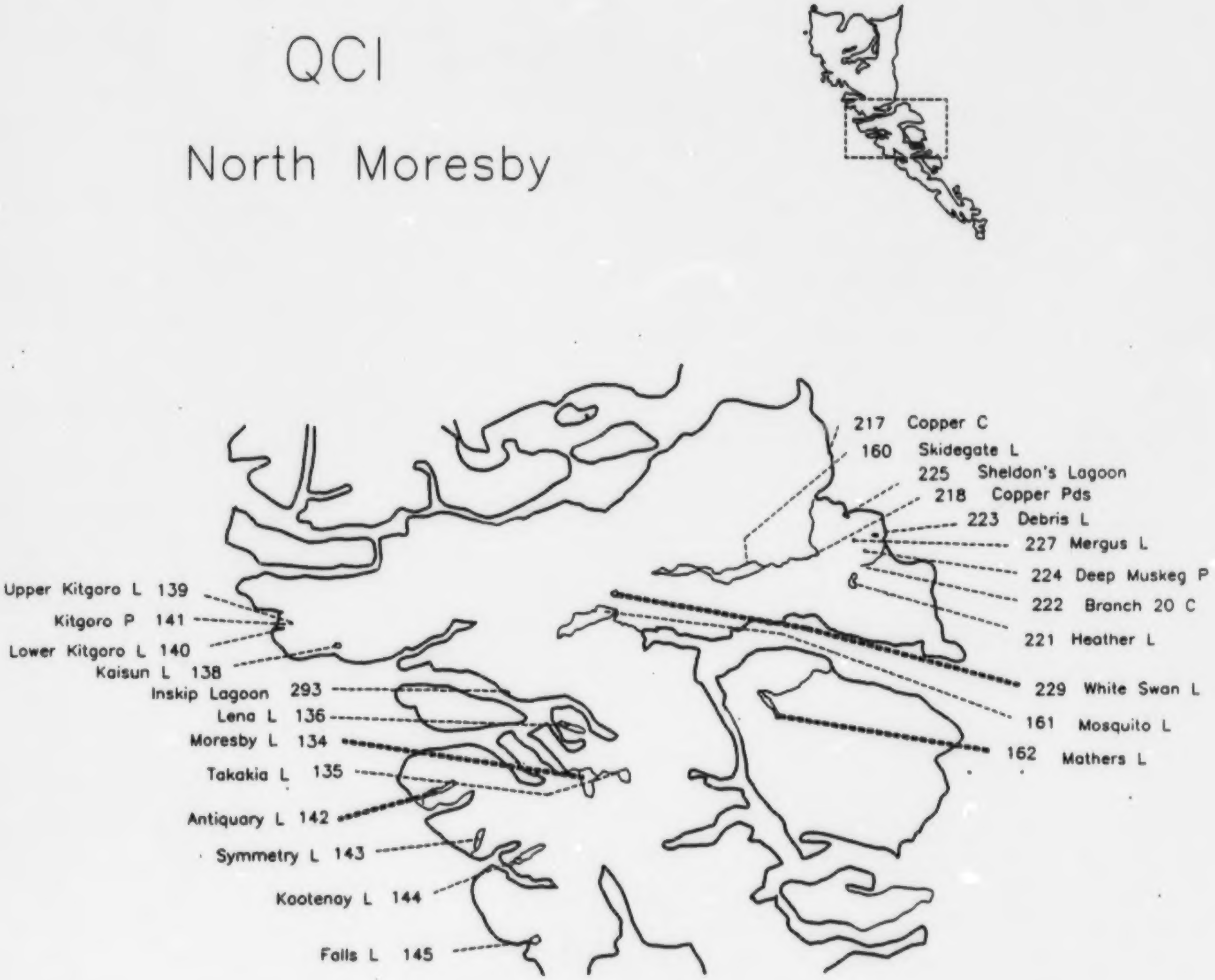

QCI
North Moresby
217 Copper C
160 Skidegate L
225 Sheldon's Lagoon
218 Copper Pds
223 Debris L
227 Mergus L
224 Deep Muskeg P
222 Branch 20 C
221 Heather L
229 White Swan L
161 Mosquito L
162 Mathers L
Upper Kitgoro L 139
Kitgoro P 141
Lower Kitgoro L 140
Kaisun L 138
Inskip Lagoon 293
Lena L 136
Moresby L 134
Takakia L 135
Antiquary L 142
Symmetry L 143
Kootenay L 144
Falls L 145

Figure 10.

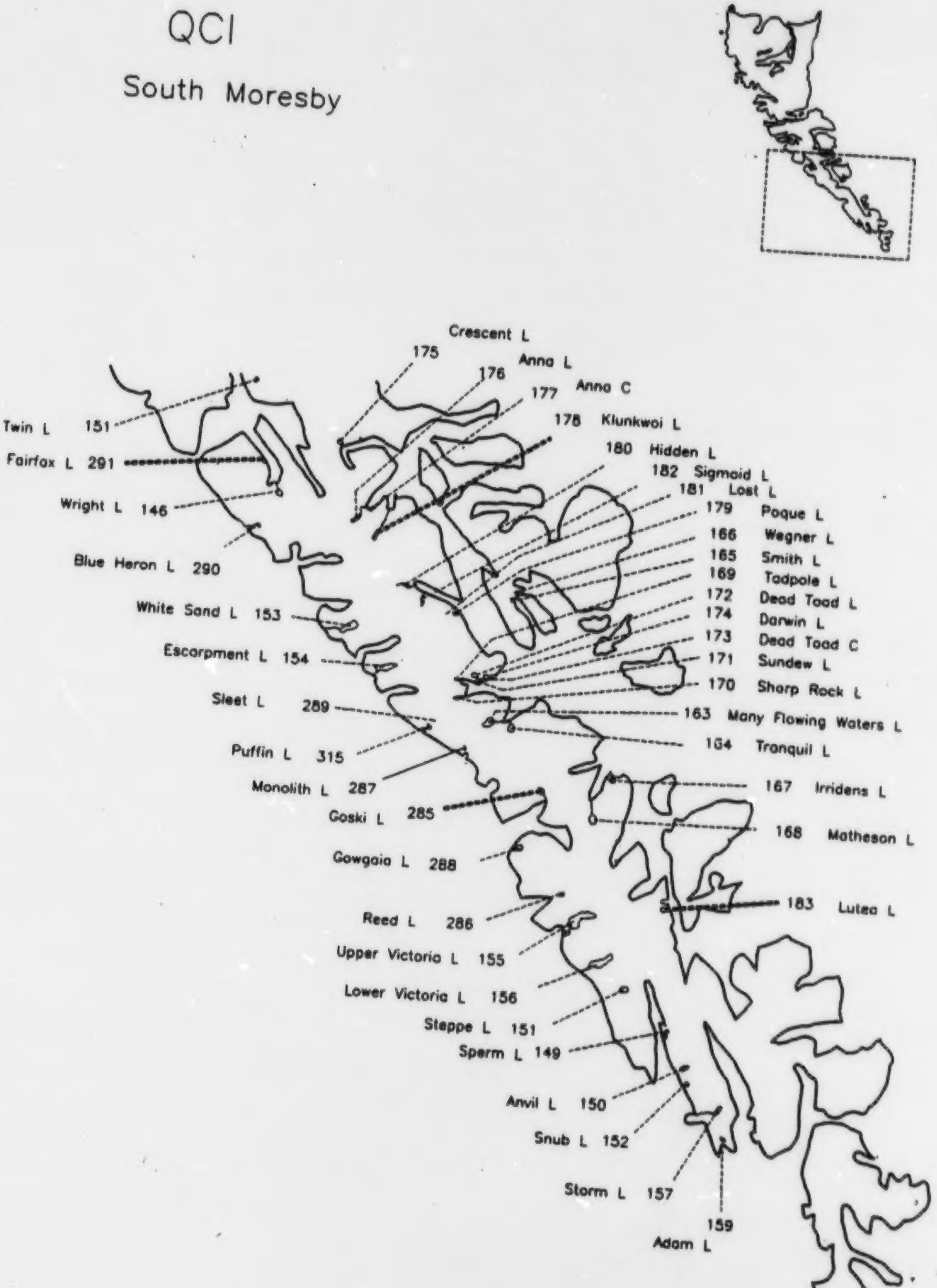

QCI
South Moresby
Crescent L
175
Anna L
176
177
Anna C
178
Klunkwoi L
Twin L 151
Fairfax L 291
180 Hidden L
182 Sigmoid L
181 Lost L
Wright L 146
179 Poque L
166 Wegner L
165 Smith L
Blue Heron L 290
169 Tadpole L
172 Dead Toad L
White Sand L 153
174 Darwin L
173 Dead Toad C
Escarpment L 154
171 Sundew L
170 Sharp Rock L
Sleet L 289
163 Many Flowing Waters L
Puffin L 315
164 Tranquil L
Monolith L 287
167 Irridens L
Goski L 285
168 Matheson L
Gowgaia L 288
183 Lutea L
Reed L 286
Upper Victoria L 155
Lower Victoria L 156
Steppe L 151
Sperm L 149
Anvil L 150
Snub L 152
Storm L 157
159
Adam L

Figure 11.

Appendix 17. Summary of boat and telescope surveys of Marbled Murrelets carried out in the Queen Charlotte Islands.

BOAT SURVEY

Shields Bay:

4 May 1990 Begin at boat launch at forest recreation site N of Shields Creek at 0938h. Foggy, drizzle, calm on water.

Time	Landmark	MAMU seen between landmarks	Total
0938	Boat launch	2,3,3	8
0945	Rock run Creek-turn back and run out center of channel	2,2,2(f),2,2,2	12
0953	Dawson Head	1,2	3
1000	MacKenzie Passage		0
1002	Clapp Basin		0
1013	W side Clapp I.		0
1023	exit Clapp Basin	2,2 (just SE of Dawson Head probably seen before)	4
1028	Dawson Head run from E shore Shields Bay to W	3(f),2,2,1,2,2	12
1044	Shields Rock (S of)	2	2
1054	NW corner Shields I.		0
	into Ells Bay	1	1
1056	W side Ells Bay	1,2	3
1101	Ells Rock	1,2,1,2	6
1105	S side Clonard Bay	1,4,1,2,2,2,2,1,2,2	19
1114	Head E N of Shields Rock	2,1,3(f),2,2,1,2,2,2	17
1119	At E shore Shields Bay	1	1

END

Appendix 17 (cont'd)

Skidegate Inlet to Tana Bay:

28 April 1990: Leave Queen Charlotte City dock at 1013h. Ran E/W transect lines starting from east side of Robertson Island. Low tide 0.3 feet at 0900h. Clear, sunny, light NW winds, water rippled.

Time	Landmark	MAMU seen between landmarks	Total
1020	Robertson I.	2 just W of Haida Pt.	2
1036	Haida Pt.		0
1042	Maple I. (S side)		0
1045	Gooden I. (N side)		0
1048	Between Roderick and Robertson I.		1
1049	Enter bay N. of Lina I.		1
1103	Leave bay		0
1120	Robber I.	blowing SE 20 in open water	0
1128	Batch I. (ran along N side of Maude I.)		0
1131	Lina I. (S side)		0
1140	Withered Pt.		0
1143	into Kagan Bay		0
1211	Meyer I.		0
1229	Slatechuck Its.	1,2,2,2	7
1248	Anthracite Pt.	2	2
1253	Josette Pt.-along NE shore Long Inlet	2(1,2w),2(1fm),2(1sm),2,2,2(1fm), 1,3(1w),2,2(1w),2(f),2,2(1mm), 1,1,2,2,2,2,2,2,2(1mm),2,2(1fm, 1mm)	46
1315	Head Long Inlet-along SW shore		0
1328	Young Pt.	1	1
1342	Sandstone Is.		0
1346	Saltspring Bay		0
1415	Scalus Is. (short break)		0
1433	Christy Bay		0
1438	N side Legace I.-still SE	20 in open water	20
1416	? I.		0
1503	Maude I. (W side)		0
1515	Heading toward Skidegate Narrows	2	2
1541	Entering East Narrows		0
1552	Exit East Narrows		0
1553	Trance Inlet (E side)	2	2
1603	Head of inlet		0
1607	West side of inlet		0
1616	Leave Trance Inlet		0
1621	Enter West Narrows		0
1626	Leave West Narrows		0
1637	Mercer Pt.	2,2,2,2,1,2,3,2,2(1mm),2,2,2, 2,2,2,2,2,2,2,2,2,2	44
1740	Enter Tana Bay	2(1mm)	2
1750	Head of bay (stopover)		0
1842	Tana Bay	2,2,2	6

f= flying; sm=start moult; mm=mid-moult; fm=finish moult; w=winter.

Appendix 17 (cont'd)

Queen Charlotte survey to Long Inlet:

7 May 1990 Leave Queen Charlotte City at 1353. Overcast, sea rippled, no fog.

Time	Landmark	MAMU seen between landmarks	Total
1353	Leave Queen Charlotte City		0
1402	SE end of Lina I.	2,1	3
1411	Winifred Pt.		0
1420	Meyer I.		0
1440	Josette Pt.	2,2,1	5
1445	Long Inlet NE side	2(1mm),1,1,2,1(f)	7
1457	Head of inlet	2,3,2,2,1,2,1 (total in inlet = 20)	13
1508	SW side of inlet		0

mm= mid-moult, f=flying

Long Inlet

11 May 1990

Time	Landmark	MAMU seen between landmarks	Total
1743	SW side of inlet	2,2(1fm),1 - birds toward centre of inlet at SE end	5
1751	Young Pt. - NE side of inlet	10 singles; 25 pairs; 7 groups of 3; 1 group of 4 2 groups of 6; 2 groups of 7 1 group of 9; 1 group of 22	142

All big flocks in center of inlet at SE end. Singles and pairs mostly near NE shore. No birds in top 1/3 of inlet near head.

END

Appendix 17 (cont'd)

Long Inlet to Queen Charlotte City; zig-zagging area east of Long Inlet

12 May Drizzle, calm, low tide.

Time	Landmark	MAMU seen between landmarks	Total
0845	SW side of Long inlet	1,2,6,2,2,1,2(1w),1,1,2,4	24
0855	Young Pt. NE side of inlet	1,2,4,2,4,2,3,3,2,2,2,8,4, 2(1w),2,1,2,2,2,2,1,1,2,3,2,1	62
0908	Head of Long Inlet	(total for inlet = 84)	
0918	Young Pt.	5(f),2(f),3(f),5,2	17
Times	Berry I.		0
not	Anthracite Pt.		0
re-	Sandstone I.	4,2,2,2	10
cor-	Josette Pt.	1,3,3,1	8
ded	Gust I.		0
	Anthracite Pt.	1	1
	Canoe Pt.		0
	Claudette Is.		0
	Withered Pt.		0
	Balch Is.		0
1030	Queen Charlotte City		0
			0

w=winter; f=flying

Queen Charlotte City to Government Creek:

9 July Sea calm, heavy rain, low cloud

Time	Landmark	MAMU seen between landmarks	Total
1920	Leave Queen Charlotte City		0
Times	Balch Isl	1,3	4
not	S of Lina I.	2,1(with fish), 3(f)	6
re-	W of Maude I.		0
cor-	Skidegate Channel	3,1,1	5
ded	East Narrows		0
	West Narrows		0
2010	Government Creek	1, 6 pairs; 1 group of 3 1 group of four; 1 group of 7 1 group of 9 (1 with fish; 2 suspected juveniles)	36

f = flying

Appendix 17 (cont'd)

Observations from troller "Lady Julia"

1983 - 1989

Date	Landmark	MAMU seen between landmarks	Total
1983			
7 Aug	Slag Rock to Langara	2	2
9 Aug	Cape Naden to Strae I	3	3
13 Aug	Kiusta	1	1
15 Aug	Kiusta - Henslung Cover	1	1
23 Aug	Cape Edenham to 7-mile	3	3
24 Aug	Masset inlet to Striae I	3	3
24 Aug	Pillar Bay	4	4
26 Aug	Cape Naden to 7-mile	6	6
31 Aug	Coho Point	1	1
9 Sept	Coho Point	1	1
23 Sept	Coho Point	3	3
May 1984	Masset Inlet	150+	150
1986			
2 Aug	Masset inlet and bar	2	2
6 Aug	Masset Bar	15 (11wp)	15
6 Aug	7:00 p.m. Masset Bar	1 with food and imm. near	1
10 Aug	Coho Point	1	1
12 Aug	Pillar Bay (p.m.)	35-50	50
16 Aug	Masset Inlet	2 (w.pl.)	2
17 Aug	Coho Point	2	2
19 Aug	Jalun River to Bird Rock	10	10
20 Aug	Bird Rock to Shag Rock	4	4
23 Aug	Bird Rock area	10	10
24 Aug	Bird Rock to Coho Pt.	1	1
26 Aug	Pillar Bay; 14 fthms	9 (w.pl.)	9
27 Aug	Bird Rock area	7	7
30 Aug	Bird Rock area	2	2
4 Sept	Masset Bar; 14 fthms	2	2
14 Mar 89	7-Mile to Cape Edenshaw	3 (w.p.)	3
1988			
11 Apr	Entry point	2	2
1 May	Masset Inlet	2	2
10 Apr	Entry point	1	1
22 May	Masset Inlet	2	2
1989			
1 July	Cape Edenshaw	9	9
1 July	Bird Rock (Cape Naden)	8	8
1 July	Pillar Bay	2,3,3 feeding	8
2 July	Jalun River	2	2
3 July	Jalun River 25-30 fthms	3-5 (2 imm.)	5
3 July	Cape Naden to Edenshaw	4,1,2,1,2,5,5	20
4 July	7-mile to Edenshaw	4,1,4,8,2,2,5,1,5,4,8,5	49
9 July	Shag Rock to 7-Mile	4,2,4,2,2,2,3,5,8	32
12 July	Entry Pt. to Bird Rock	20+	20
13 July	Bird Rock (Cape Naden)	4,3,1	8
14 July	7-Mile to Edenshaw	9,11,4,3,4,6,9,15,2,3	66
14 July	7-Mile to Masset Bar	3,9,8	20

Appendix 17 (cont'd)

Observations from troller "Lady Julia" (continued)

1983 - 1989

Date	Landmark	MAMU seen between landmarks	Total
15 July	Masset to Pillar Bay	6,1,2	9
15 July	Pillar Bay	1,5,9,1	16
19 July	Masset Inlet to Green Can.bouy	4,10	14
19 July	7-Mile to Edenshaw	4(imm),72,22 4-4-42	148
19 July	Naden open	1,2	3
19 July	Shag Rock to Pillar Bay	2,3	5
20 July	Pillar Bay	many juvenile calling and begging; 182-323-14	519
27 July	Masset Bar	25	25
27 July	7-Mile to Cape Naden	12,8,18	38
6 Aug	Cape Edenshaw; 7-Mile (5 fthms)	present	
7 Aug	Masset Bar (off circle)	10	10
12 Aug	Langara I.	1 either w.pl. or imm	1
16 Sept	Masset Bar	1	1
18 Sept	Cape Edenshaw to entry pt.	1	1

Appendix 17 (cont'd)

Shields Bay - Rennell Sound

29 May 1990- Calm in inner part of Shields Bay and Clapp Basin.
Heavy chop with white caps in northwest portion.

Time	Landmark	MAMU seen between landmarks	Total
1509	Shelley Creek mouth		0
1518	Rockrun Creek mouth		0
1524	midchannel Dawson Head - Shelley Creek		0
1525	east shore Shields I. at Dawson Head		0
1543	Head of Clapp Basin		0
1554	N end of enclosed basin between Shields and Clapp Islands		0
1559	East end of Channel between Clapp I.		0
1603	Dawson Head, turn W along Shields I. shore	3,2,5,17,3	30
1609	South of Shields Rock		0
1615	East end Ells Bay		0
1620	West of Ells Rocks	1	1
1630	Southeast end of Clonard Bay	2,2,10,7,1(w)	22
1645	North of Shields Rock		0
1655	Shelley Creek mouth		0
		TOTAL	53
30 May 1990	SE wind rippled; rolling swells out at Gospel Island		
0826	Shelley Creek mouth		0
0831	Rockrun Creek mouth		0
0836	Midchannel Dawson Head-Shelley Cr.		0
0837	E shore Shields I at Dawson Head		0
0846	Mackenzie Passage		0
0855	Head of Clapp Basin		0
0900	E end of channel between Clapp I.		0
0913	Dawson Hd., turn W along Shields I.		0
0923	E end Ells Bay		0
0927	W of Ells Rocks - turn E	2	2
0932	E side Shields Rock		0
0941	Islet on E side Shields Bay, opposite Clonard Bay	2,2,2,1	7
0947	Clonard Bay, turn N	2(1w),2,4,2,1,2,3	16
1010-1030	Gospel I., turn due N	6,2,9	17
1050	Creek mouth and bay directly N Gospel I.	18,2	20
1117	Gospel I.	1,8	9
1132	Gospel Pt.	2	2
1137	Riley Pt.	9,2,2,2,1,1,2	19
	Islet on E side Shields Bay opposite Clonard Bay-Shelley Cr. mouth		0
		TOTAL	92

Appendix 17 (cont'd)

Rennell Sound

31 May 1990 - Bright sun, light chop - turning to heavy chop near Richardson Head, northwest wind and swell.

Time	Landmark	MAMU seen between landmarks	Total
1005	Shelley Creek mouth		0
1015	Islet on E side Shields Bay, opposite Clonard Bay	3,2	5
1024	Clonard Bay		0
1031	Richardson Head	2,3	5
1100	Gospel Island		0
1235	Gospel Island	2,6	8
1246	Gospel Point	1	1
1251	Riley Point		0
1300	Islet on E side Shields Bay opposite Clonard Bay		0
1307	Dawson Head		0
1315	Mackenzie Passage		0
		TOTAL	19

Shields Bay

31 May 1990 - Northwest wind blowing 10-15 knots; water choppy.

Time	Landmark	MAMU seen between landmarks	Total
1800	Clapp Basin		0
1829	Mackenzie Passage		0
1840	Dawson Head	2,8	10
1850	Shelley Creek mouth		0
		TOTAL	10

Appendix 17 (cont'd)

Rennell Sound

1 June 1990 - Clear sky, calm wind, flat smooth water becoming rippled to light chop at 1030 then moderate chop by 1200.

Time	Landmark	MAMU seen between landmarks	Total
0800	Shelley Creek mouth		0
0806	Ells Rocks		0
0810	E end Ells Bay		0
0813	Ells Rocks		0
0820	NE shore Shields Bay		0
0825	Islet on NE side Shields Bay, opposite Clonard Bay	1	1
0831	Clonard Bay		0
0851	Gospel Island	20,13,1,4,4,4(3w),1	47
0915			
1032	Creek mouth and bay directly N of Gospel Island	2,3,16,5,2	28
1103	Cove E of Cone Head	10,50,15	75
1125	S shore Gospel Island	1,1,2,4,2,2,2,2,2	18
1157	Gospel Point	1	1
1204	Riley Point	2,1,2	5
1218	Islet on NE side Shields Bay, oppposite Clonard Bay	3	3
1229	Shelley Creek mouth		0
1238	Mackenzie Passage		0
1241	Dawson Head		0
1245	Shelley Creek mouth		0
		TOTAL	178

Appendix 17 (cont'd)

Masset Inlet-Masset Sound

4 June 1990 - Wind calm, water smooth, changing to lightly rippled; some rain at 1320. Strong W wind and choppy water began at 1630.

Time	Landmark	MAMU seen between landmarks	Total
1237	Port Clements		0
1244	Martin Point	2	2
1300	Ship Island		0
1309	Collison Point		0
1315	Club Island		0
1318	Beacon on Kumdis I. shore, opposite Cook Point	2	2
1342	Hogan Point		0
1347	First islet S in Kumdis Slough		0
1352	Hogan Point		0
1354	Nadu River		0
1500			
1520	Watun Creek		0
1523	W side Masset Sound opposite Waton Creek	1	1
1544	W side of Sound opposite Hogan Point	4	4
1618	Collison Point		0
1631	Ship Island		0
1634	Ship Kieta Island	2	2
1645	S point Ship Island		0
1651	Sloop Islet	1,4,2	7
1745	Port Clements		0
		TOTAL	18

Appendix 17 (cont'd)

TELESCOPE COUNTS

Bonanza Head area - Rennell Sound

Survey from pullout on road before Bonanza Beach Recreation site - looking out into Rennell Sound with Gospel Island in centre of scan.

Date	Time	Weather	Marbled Murrelets seen	Total
24/07/90	0848-0904	Water smooth in section of bay formed by a line between the two points. Beyond this water is rippled.	1,1,2,3,1,1,2,2, 6,2,2,2,1,1,2,2, 2,2	35
25/07/90	0817-0820	NW wind - 15 knots Sea - rough chop with white caps further out.	2,2,1,2,2	9
27/07/90	0810-0830	Wind and sea calm light ripple in bands further out.	2,2,2,2,2,2,2,2,2, 4,2,4,8,32,2,12,2, 10,2,2,4,3,2,1,2,1, 2,2,2,2,2	121
28/07/90	0756-0820	Wind and sea calm.	3,1,2,2,2,2,2,5,1, 2,1,2,6,3,3,2,2,2, 2,2,2,12,2,2,2,35,2	104

Appendix 17 (cont'd)

Gray Bay to Cumshewa Head area

Date	Time	Station	Weather	Marbled Murrelets seen	Total
3/08/90	2111-2130	MAMU listening stns. #3 and #4	Water calm near shore, choppy further out beyond kelp beds.		0
4/07/90	0632-0646	MAMU listening stns. #3 and #4	NW wind 15-30 kn. Sea choppy.		0
4/07/90	1830	Headlands S of Kids Cove and and area in front of Jewel Cove	Wind and sea calm	22,1,1,2,2,1,2 1,1,2,2,1,1,1,2, 2,1,1,2,1,1,2,2, 2,1,2,2,2,1,2,2, 3,2,2,2	77
4/07/90	2112-2129	Sandy Cove [MAMU listening stns. #5 and #6	Calm water but quite dark.		0
5/07/90	0620-0624	Sandy Cove	Water calm.		0
5/07/90	1456-1502	Sandy Cove	Wind NE water - moderate chop.	1	1
5/07/90	2053-2104	McCoy Cove	Wind and sea calm.	1,1	2
6/07/90	0534-0543	McCoy Cove	Wate rippled, wind light.	2,1,2,1,2	8
6/07/90	1045-1055	McCoy Cove	Water-calm close in but further out choppy and intense head shimmer.	2,1,1	4
6/07/90	1515	From shore opposite E end Kingui Island	Water calm.	1,1,2,2,1,2,2,1, 1,1,1,2,6,1,5,1, 1,2,1,1,1,1,5,1	43

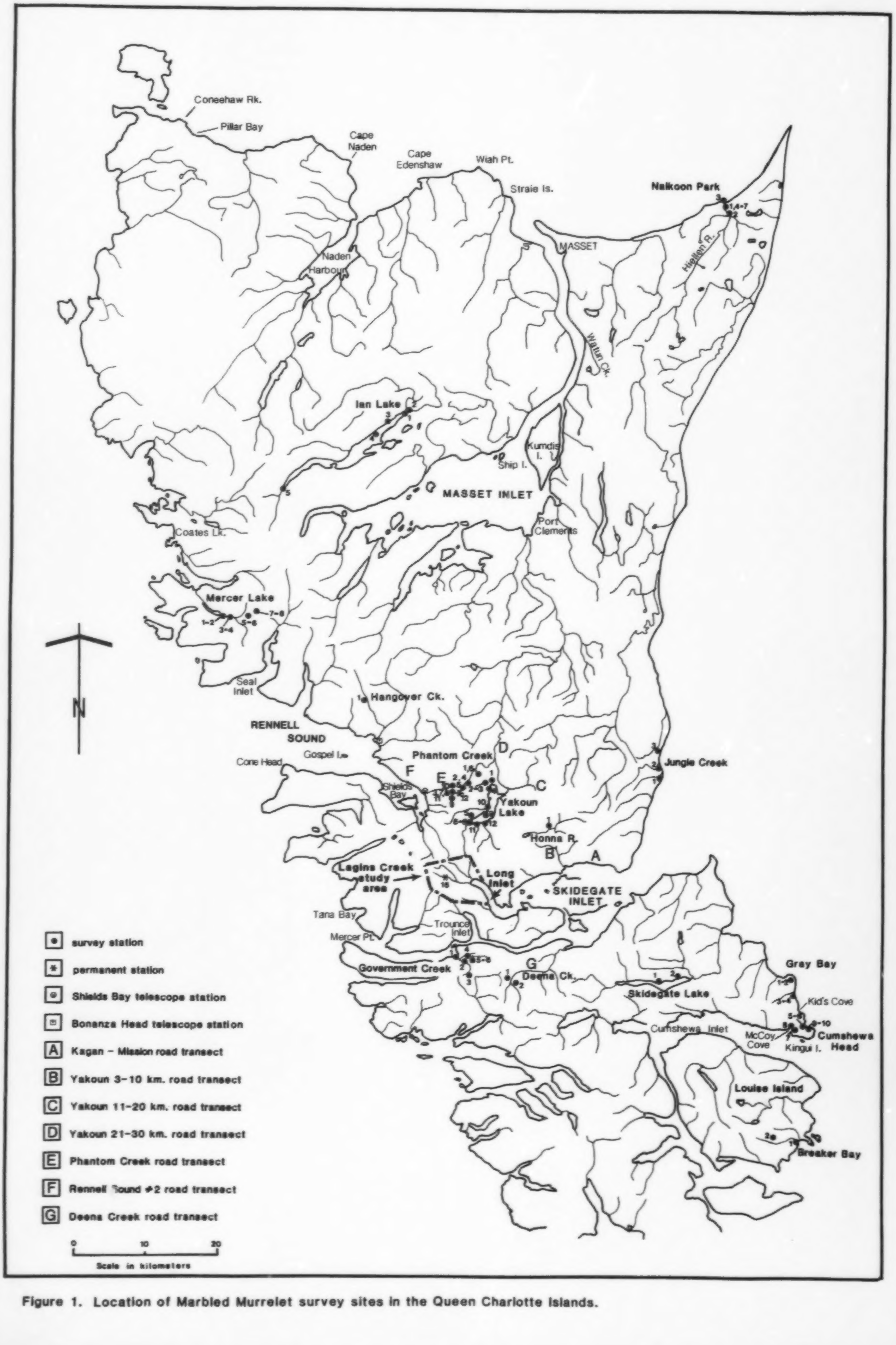


Figure 1. Location of Marbled Murrelet survey sites in the Queen Charlotte Islands.